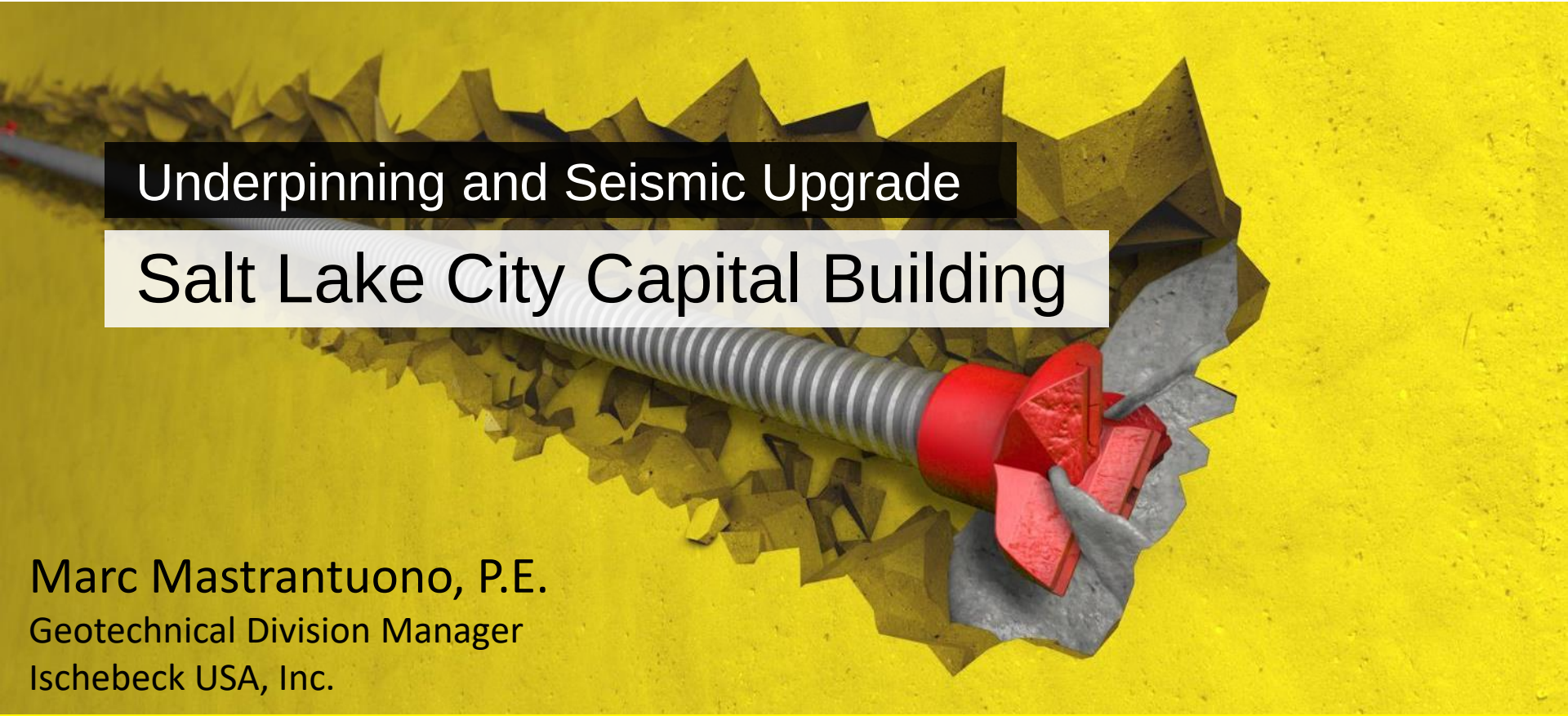
ISCHEBECK TITAN



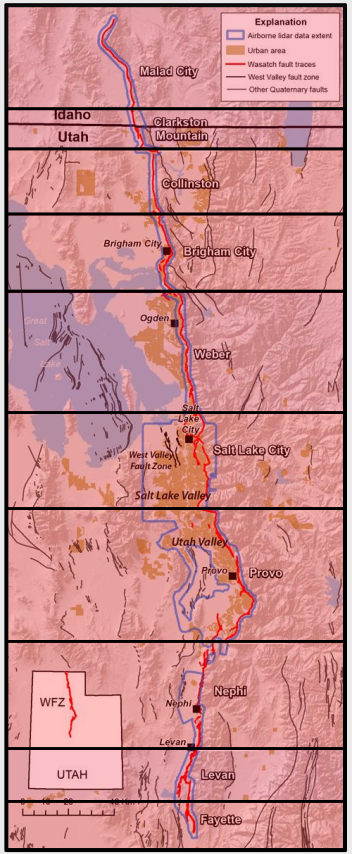
Underpinning and Seismic Upgrade

Salt Lake City Capital Building

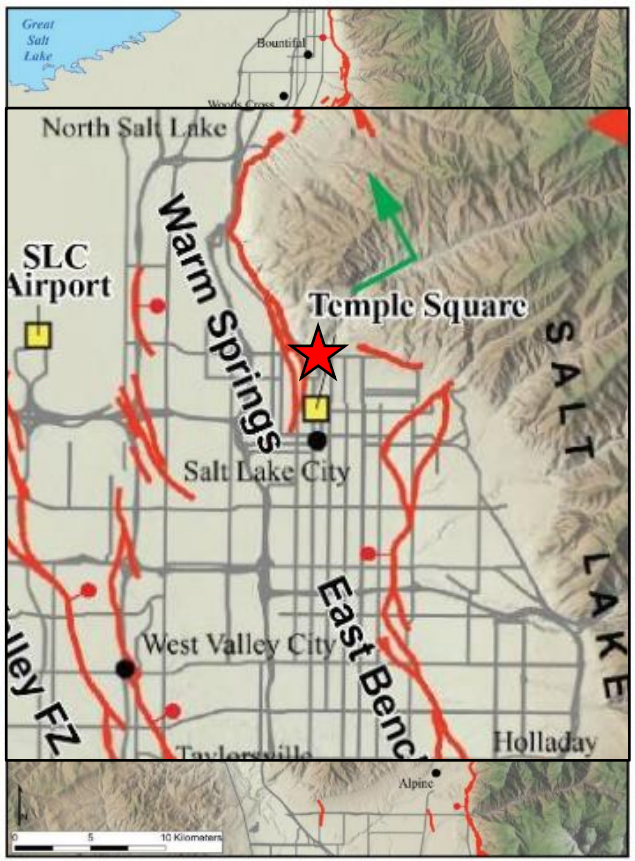
Marc Mastrantuono, P.E.
Geotechnical Division Manager
Ischebeck USA, Inc.

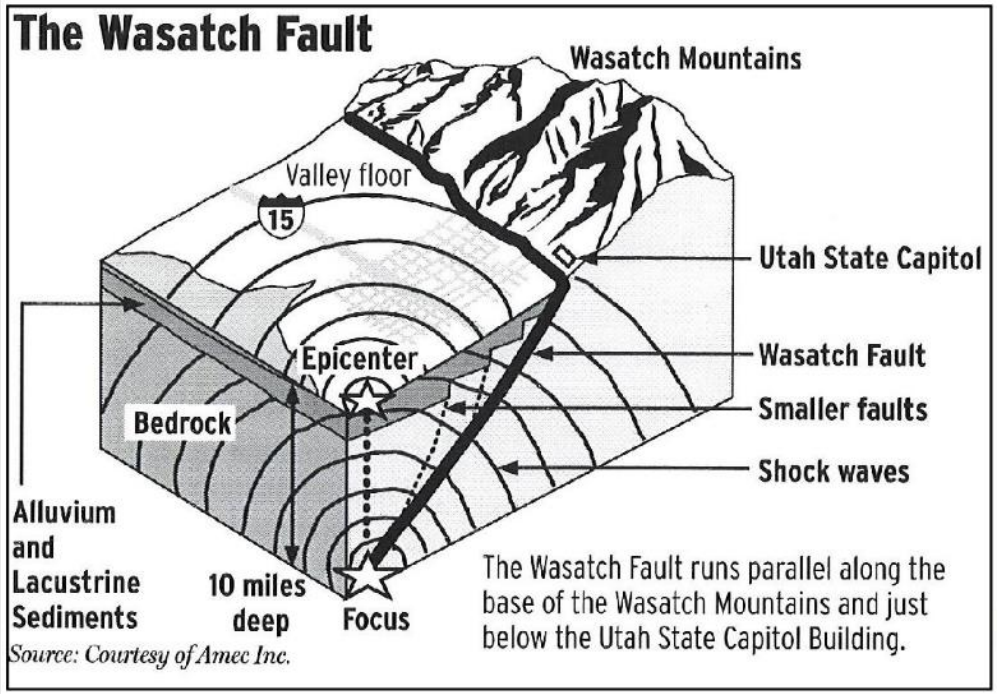
Geology – Wasatch Fault

- Located at the Western base of the Wasatch range
- Area has the greatest earthquake risk in the interior western US
- Made up of 10 segments, Avg 25 miles (40km) in length each
  - 5 central segments offer the highest risk
- Each segment has the ability to rupture independently
- Effects 1.6 million people
  - 80% of Utah residents live along the fault



Geology – Wasatch Fault

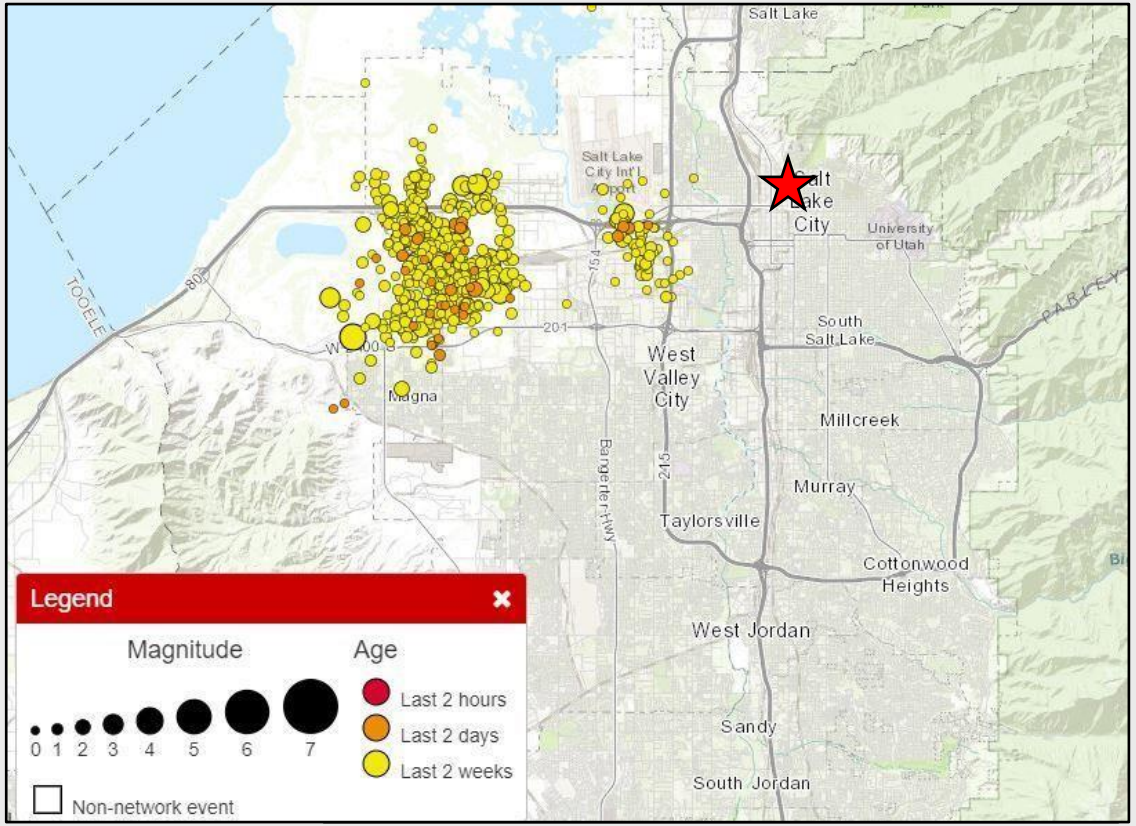




Geology – Wasatch Fault

- Most recent earthquake March 2020
- 5.7 magnitude
- 2,590 aftershocks throughout the following year.

- Over the last 10,000 years a large event has taken place every 900-1300 years.
- It's been 1200-1600 years since a 7.0 or greater event has happened along the Salt Lake City Segment.
- "Overdue for large earthquake"

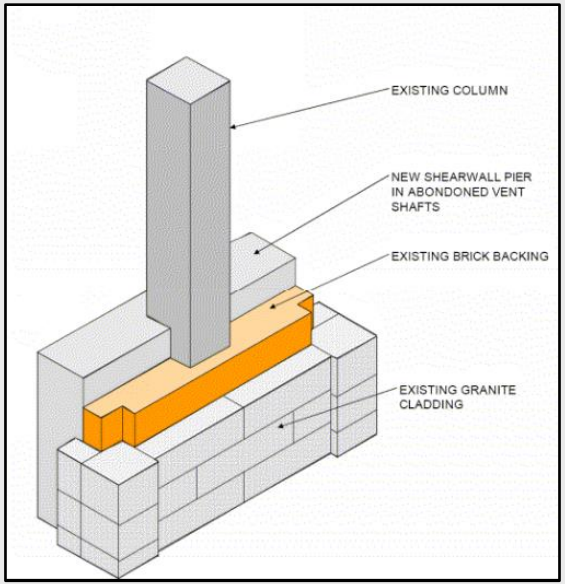


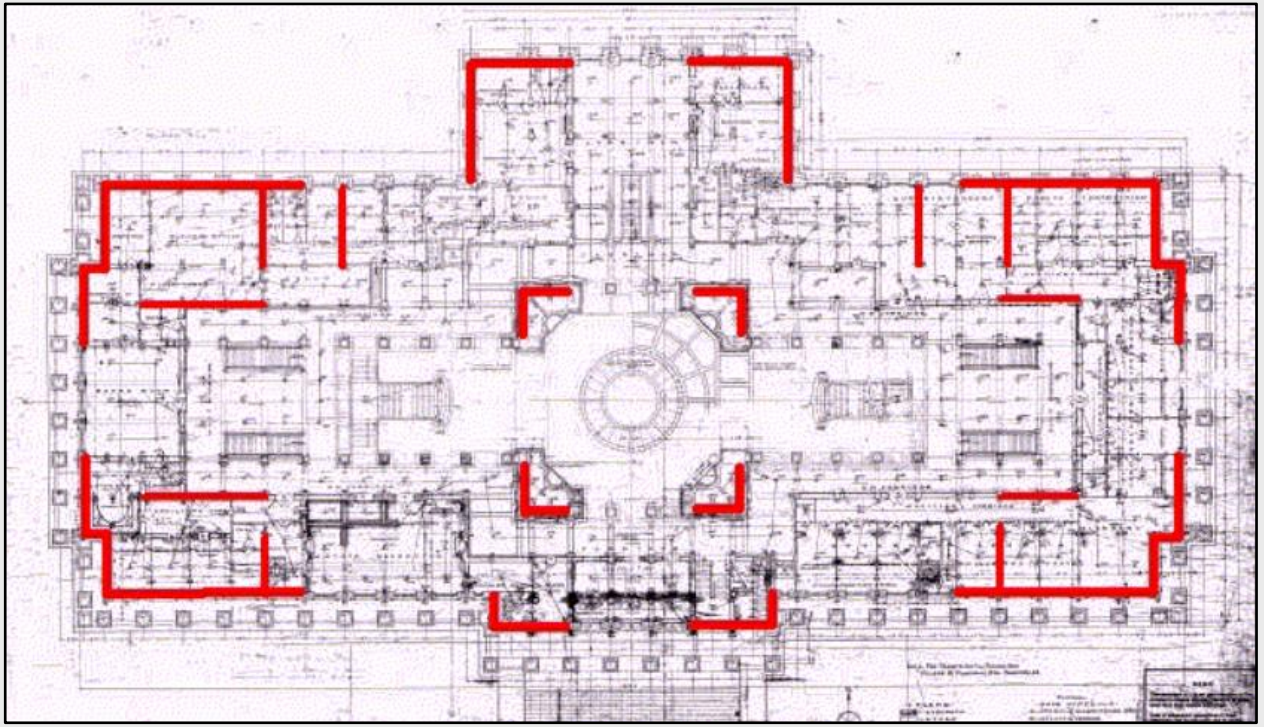
Salt Lake City Capital

- Built in the early 1900s
- 4 stories with crawl space
- Constructed using reinforced concrete frame
- Later analysis indicated the building would perform poorly during a seismic event
- The concept of seismic design did not exist 100 years ago
- $200 million seismic upgrade from 2004 to 2008

Shear Walls

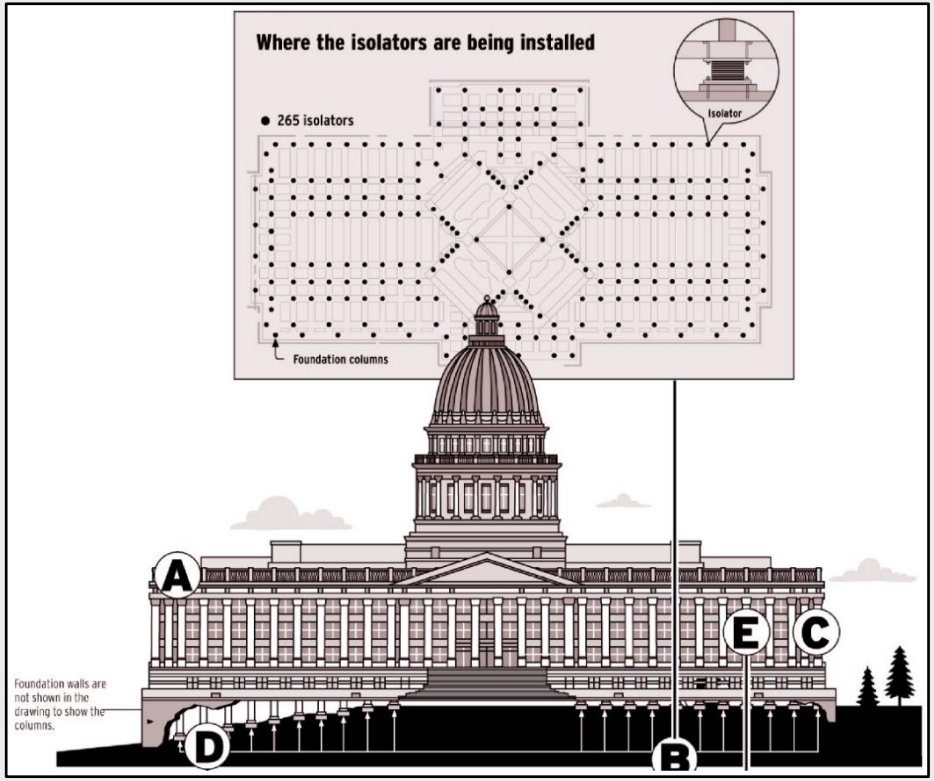
- New shear walls





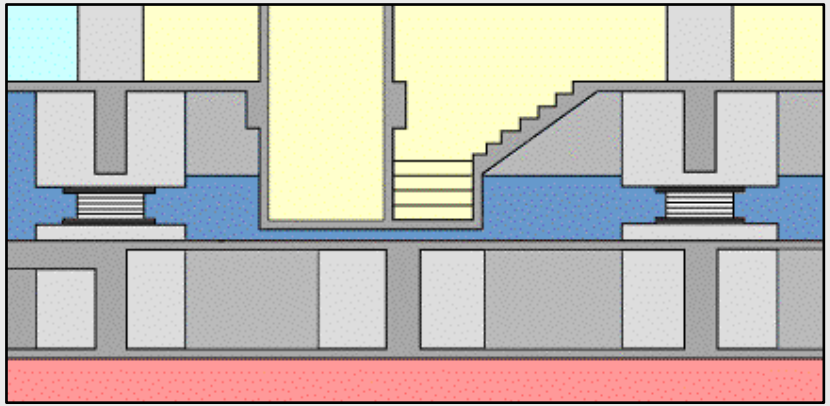
Challenges

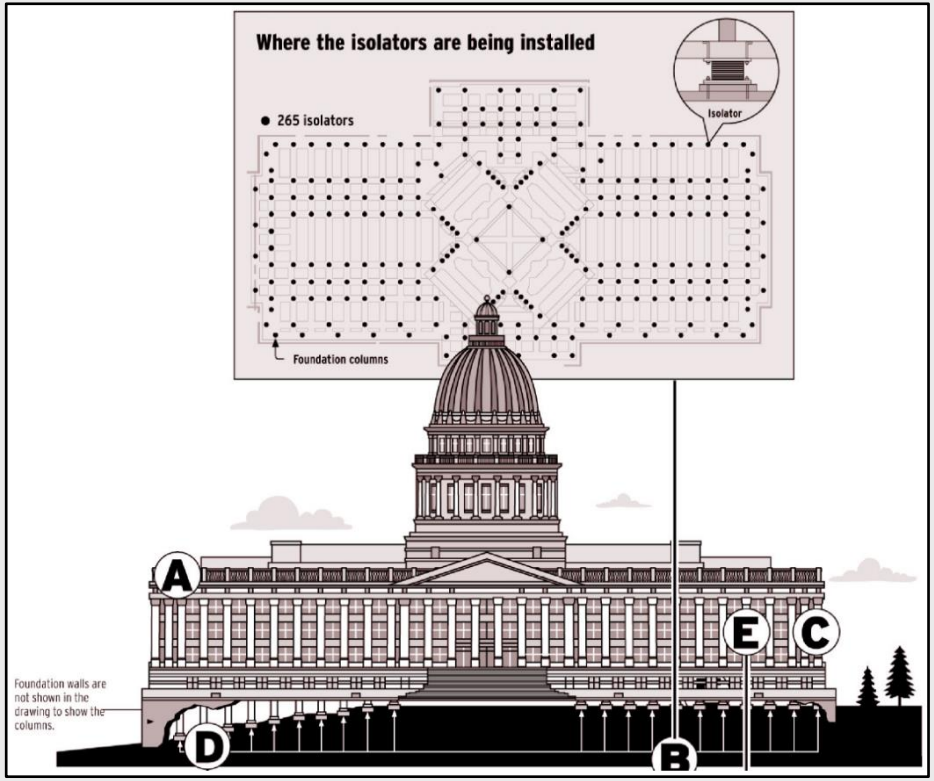
- Plan required complete removal of existing foundation system
  - Other solutions would have caused damage to the original historical structure. Higher overall cost.
- Very heavy structure. Roughly 2x the weight of modern office building of comparable size
  - Dome amplifies seismic forces due to weight
- Structure built on slope
  - West side of building had limited access
  - Required breaking out portions of floor above
- During construction, the structure could not sustain more than 1/16" of movement



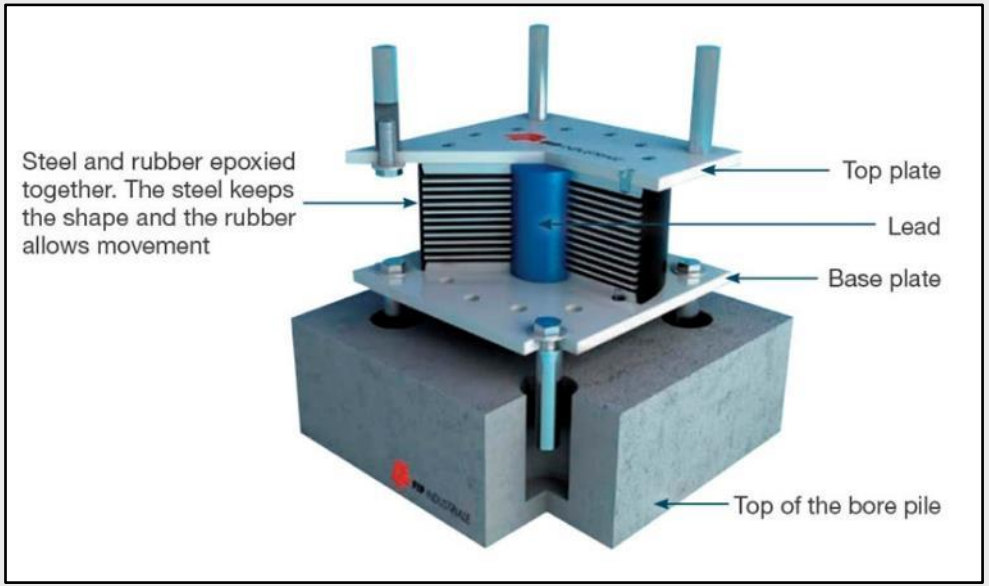
Base Isolator

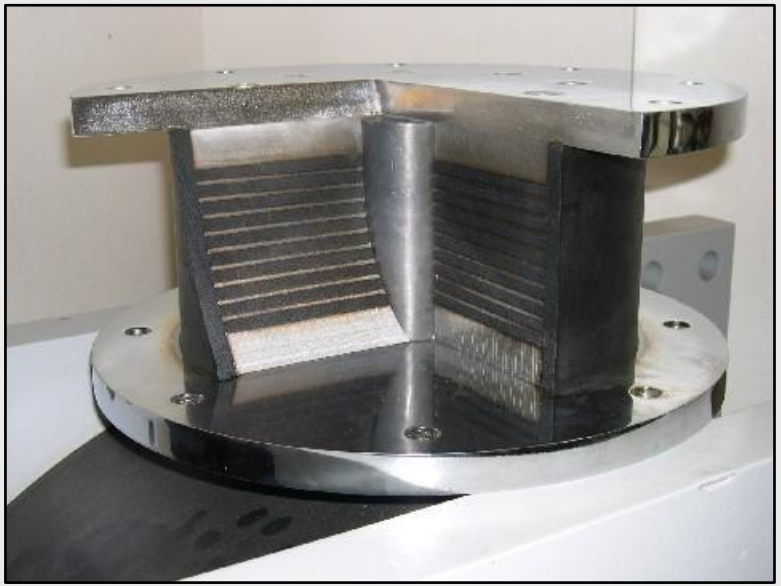
- 265 base isolators to be installed
  - Base Isolation is one of the most popular and effective tools against earthquake forces
  - Decouples structure from the structure base (foundation)
  - Vertically stiff
  - Horizontally flexible



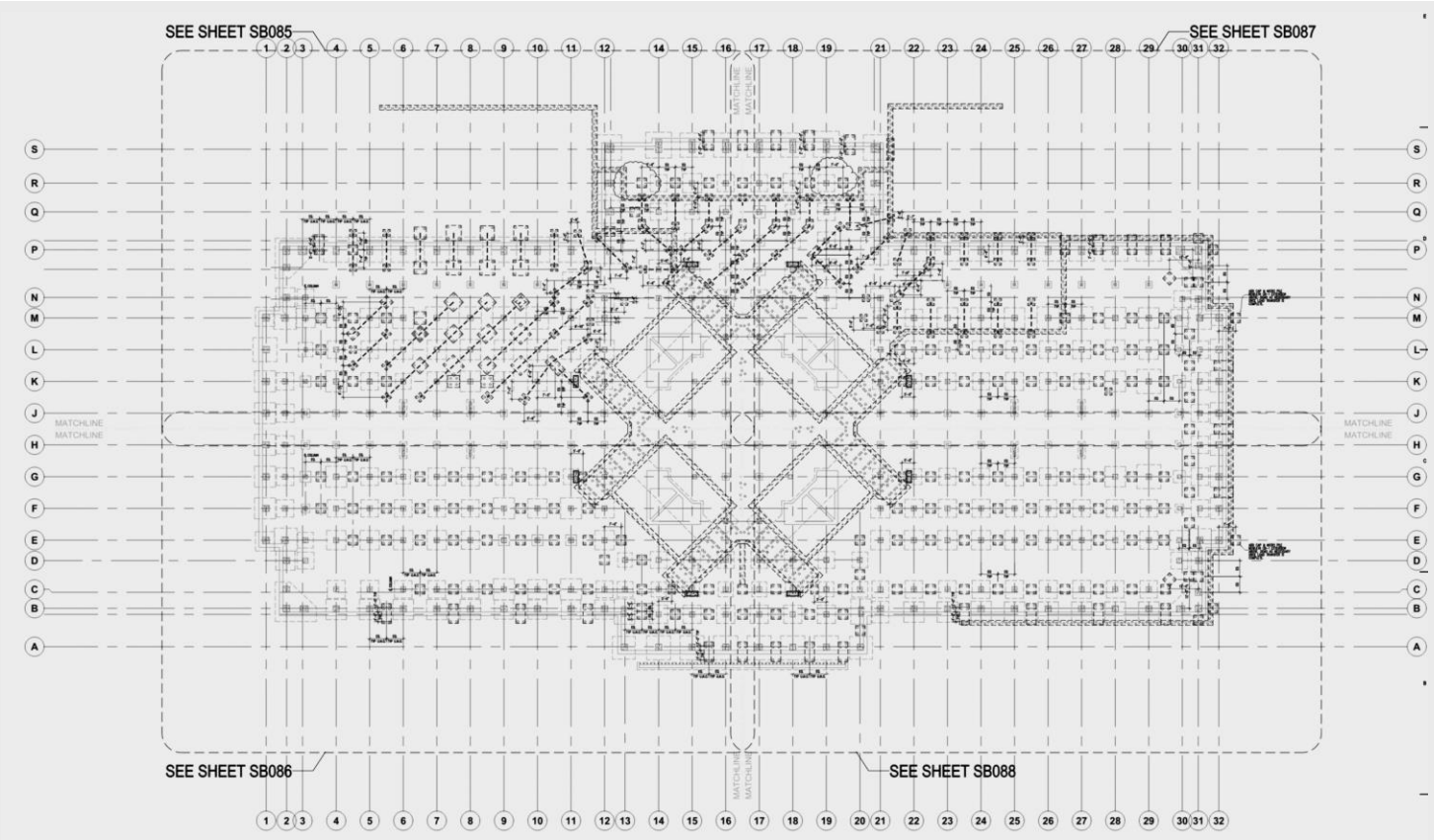


Base Isolator



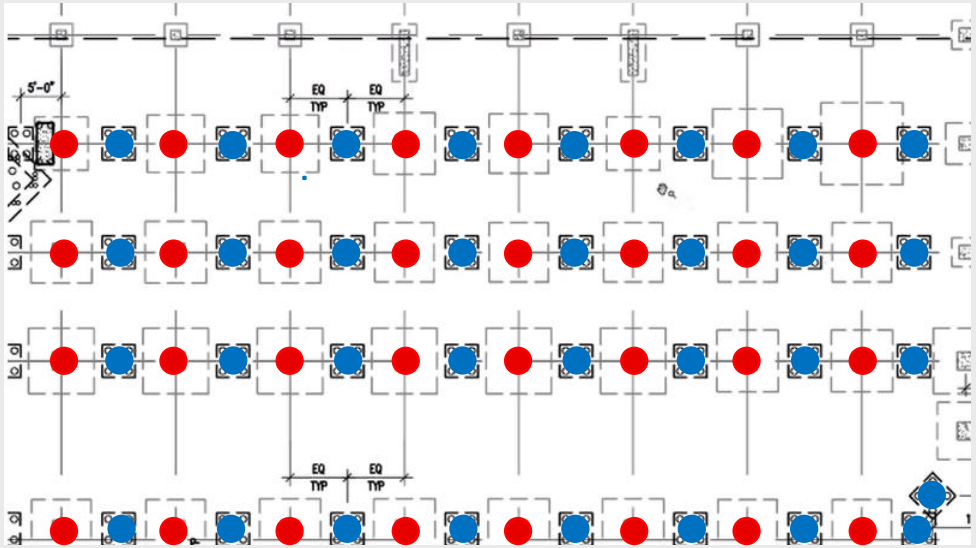


Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit

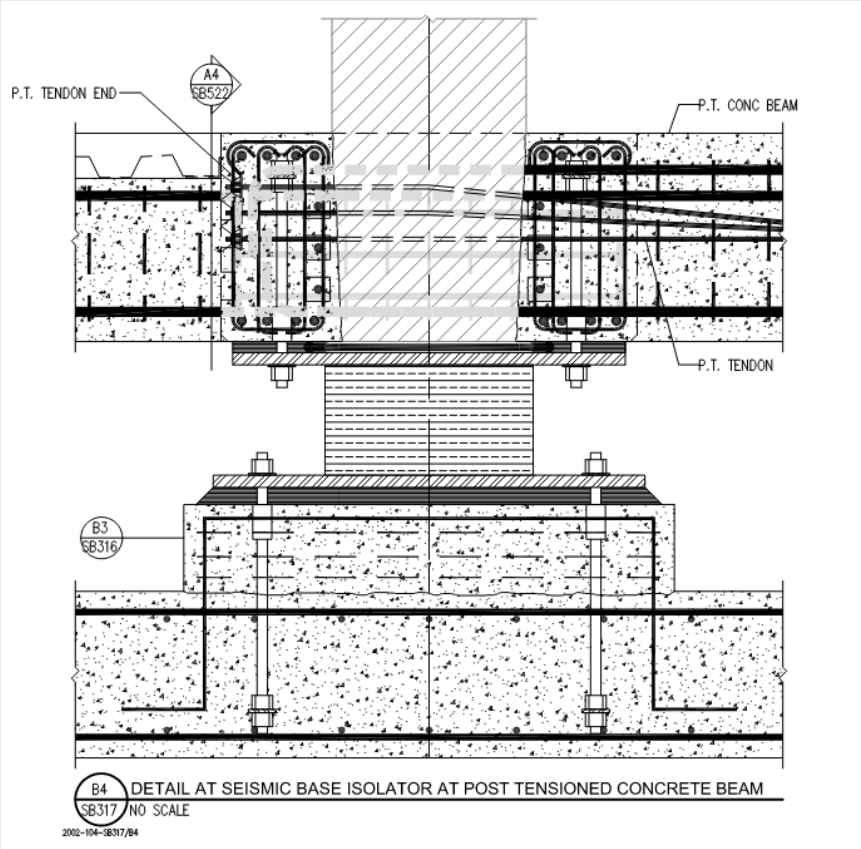
- Columns 14ft O.C.
- “Thousands of Micropiles”
- Over 3000 micropiles
- Pile groups of TITAN T30/11 and TITAN T40/16
- Column loads Ranged from 200kips – 900+ kips



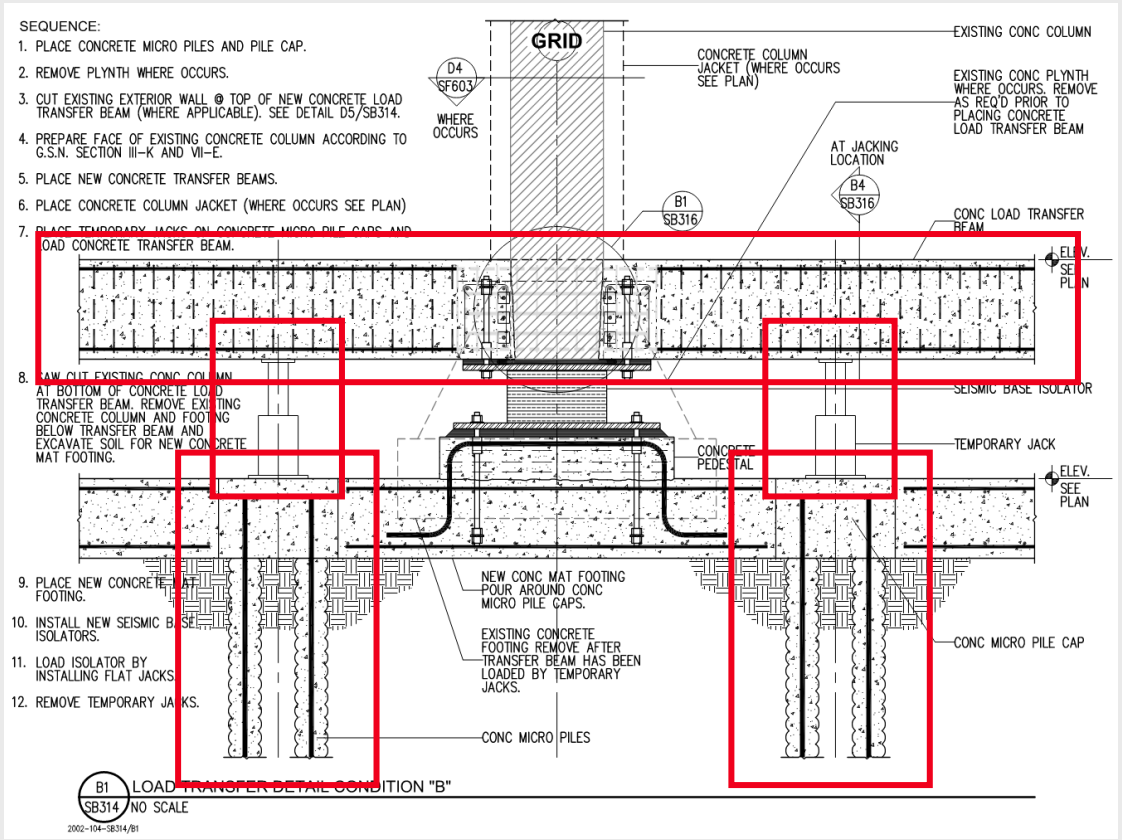
Isolator

Pile Cap

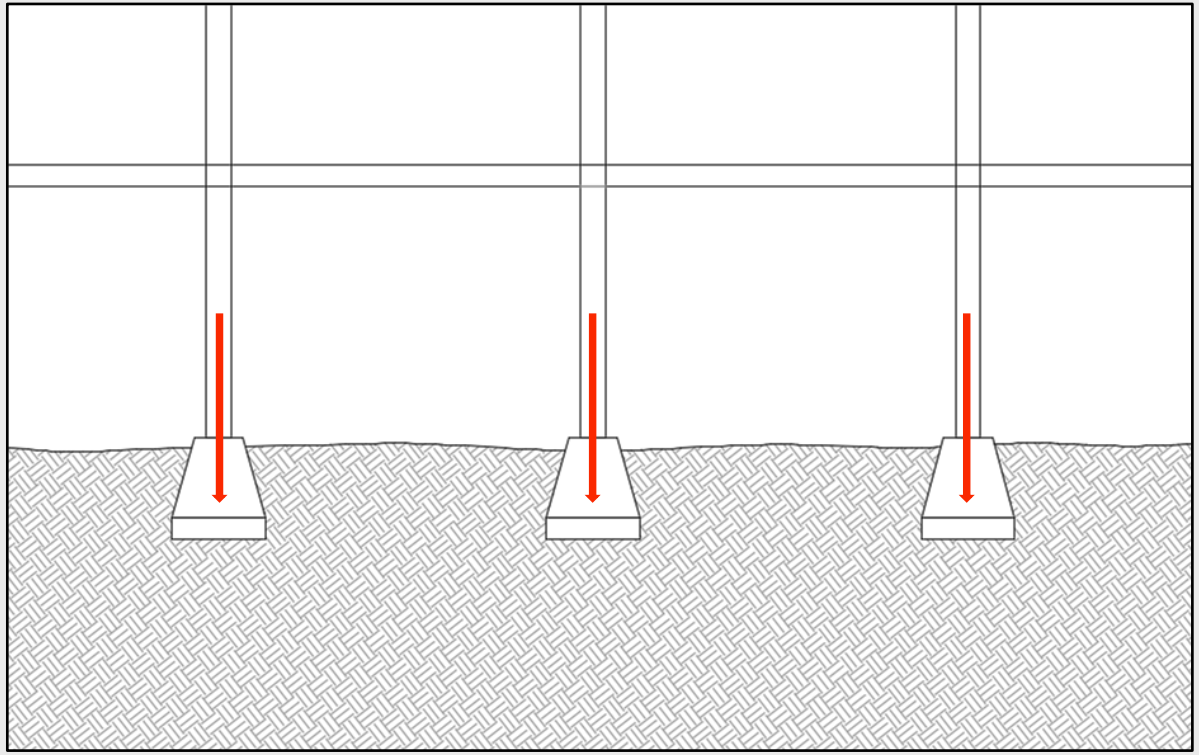
Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit



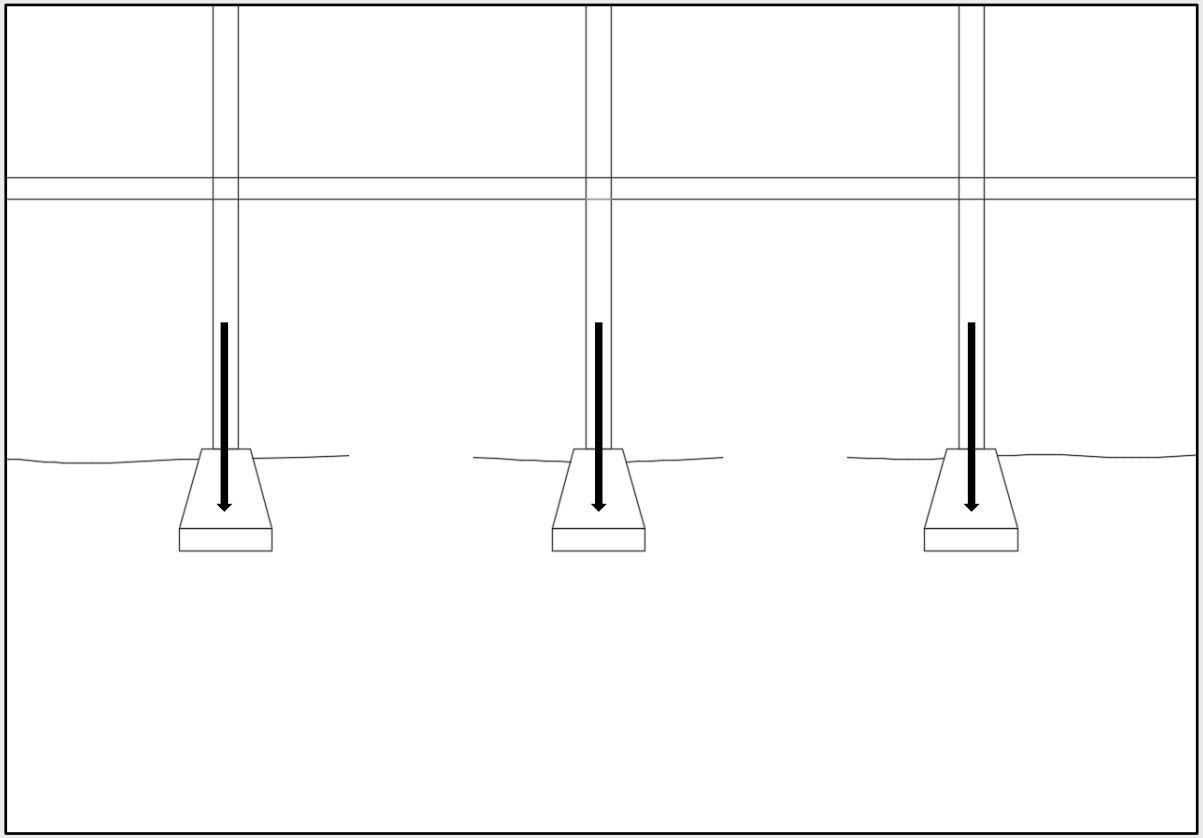
Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit

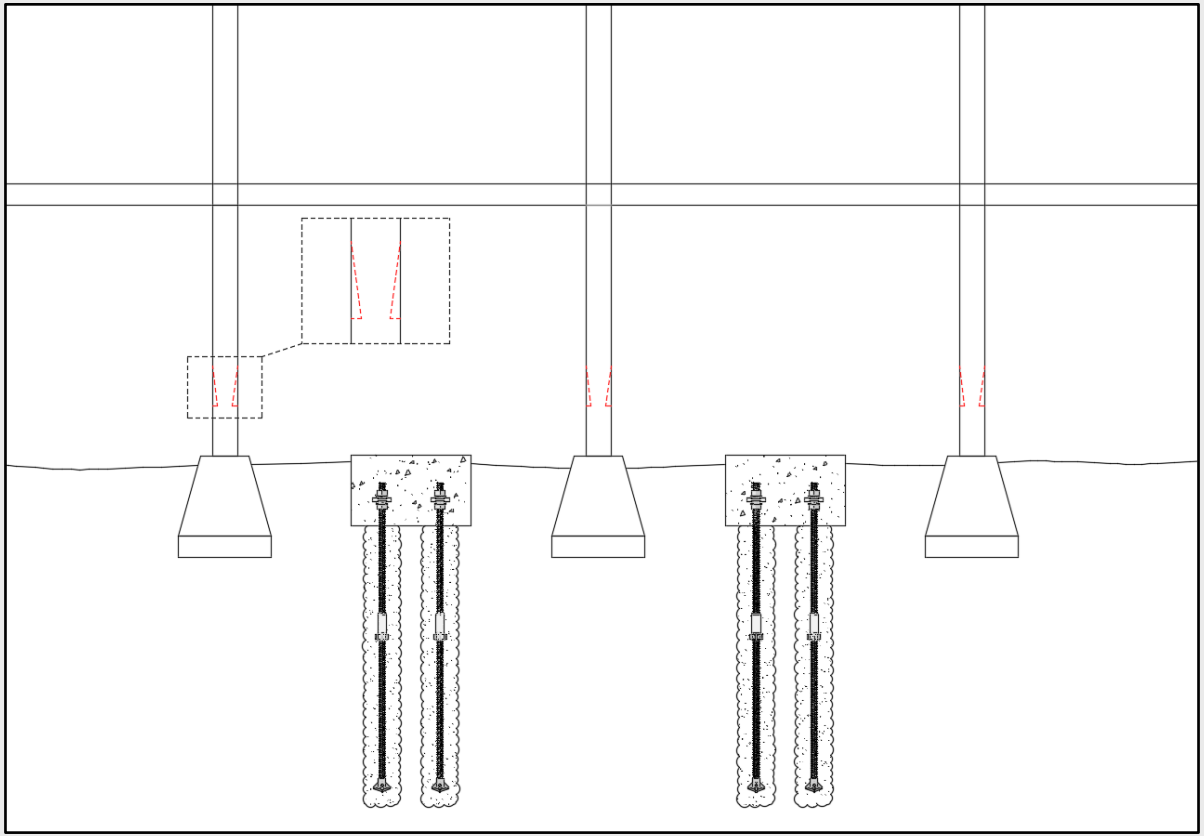
- East Side of building

Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit

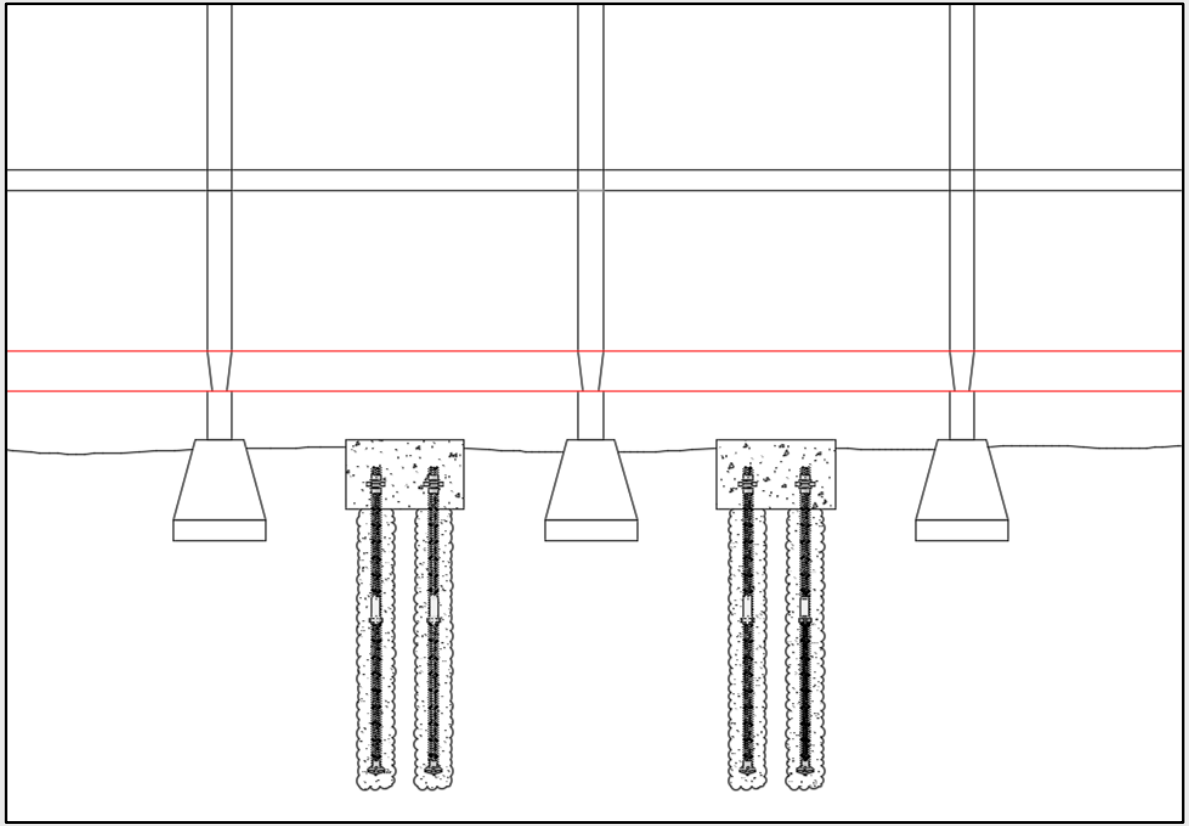
Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit

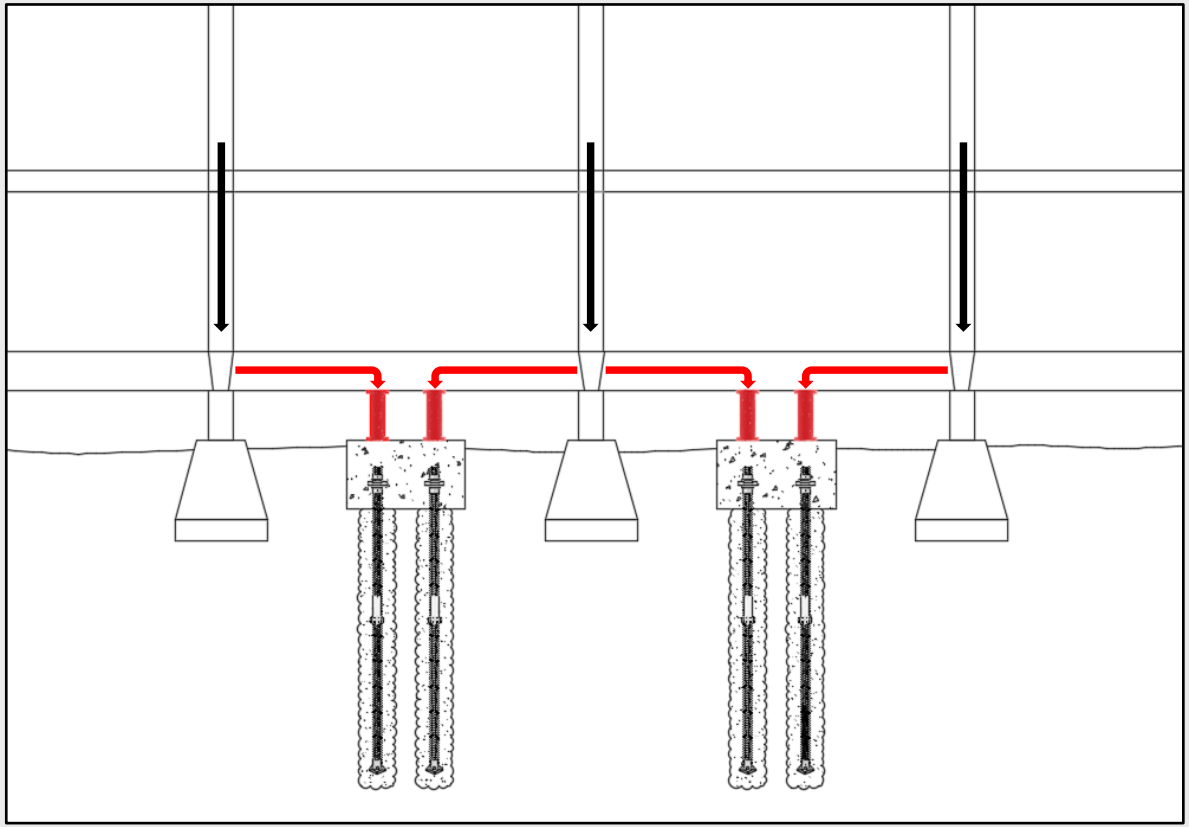
Utah State Capitol Seismic Retrofit

- 30” temporary load transfer slab
- ~ 5ft wide



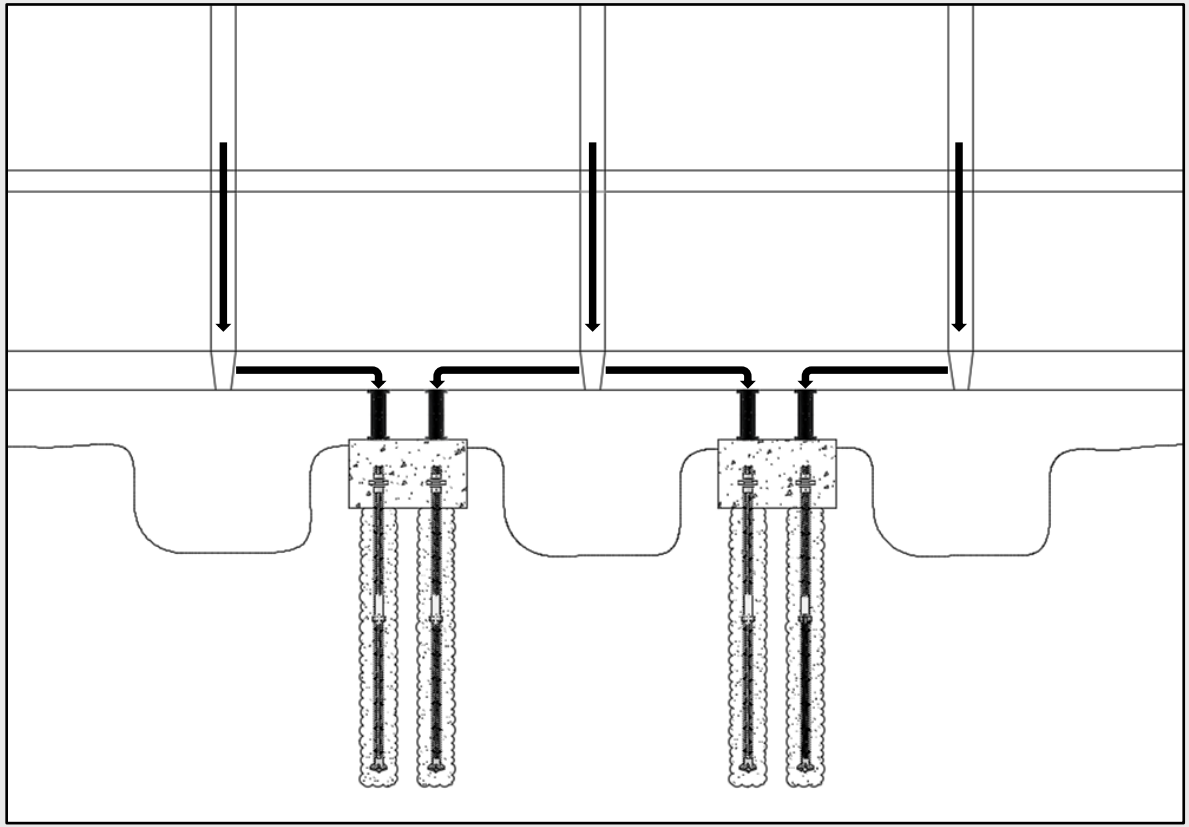
Utah State Capitol Seismic Retrofit

Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit

Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit

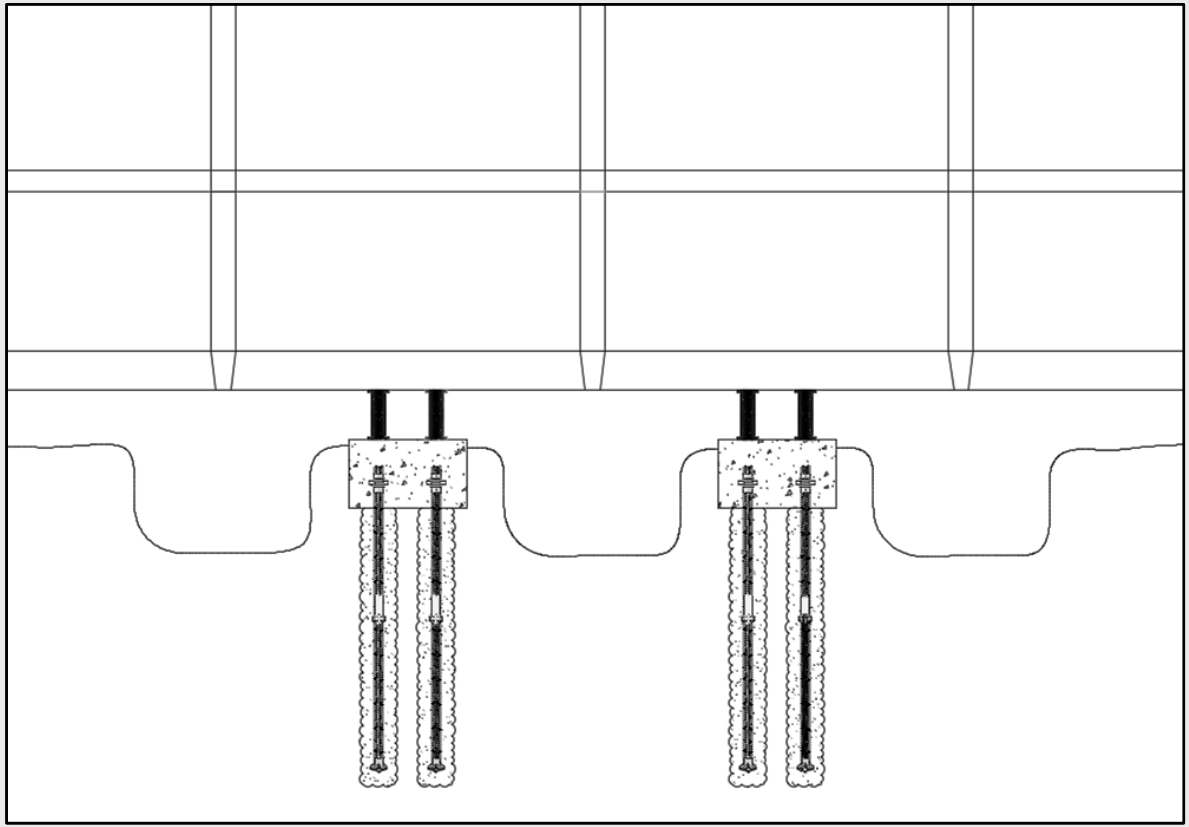
- In areas where columns were not symmetrical, steel beams were used to transfer the load
- Approximately 40 columns removed at a time

Utah State Capitol Seismic Retrofit

- Jacks to apply pressure just until there was a load transfer
- Not wanting to lift

- During construction, the structure could not sustain more than 1/16” or movement
- Actual movement up to 1/1000th inch

Utah State Capitol Seismic Retrofit



Utah State Capitol Seismic Retrofit

Utah State Capitol Seismic Retrofit

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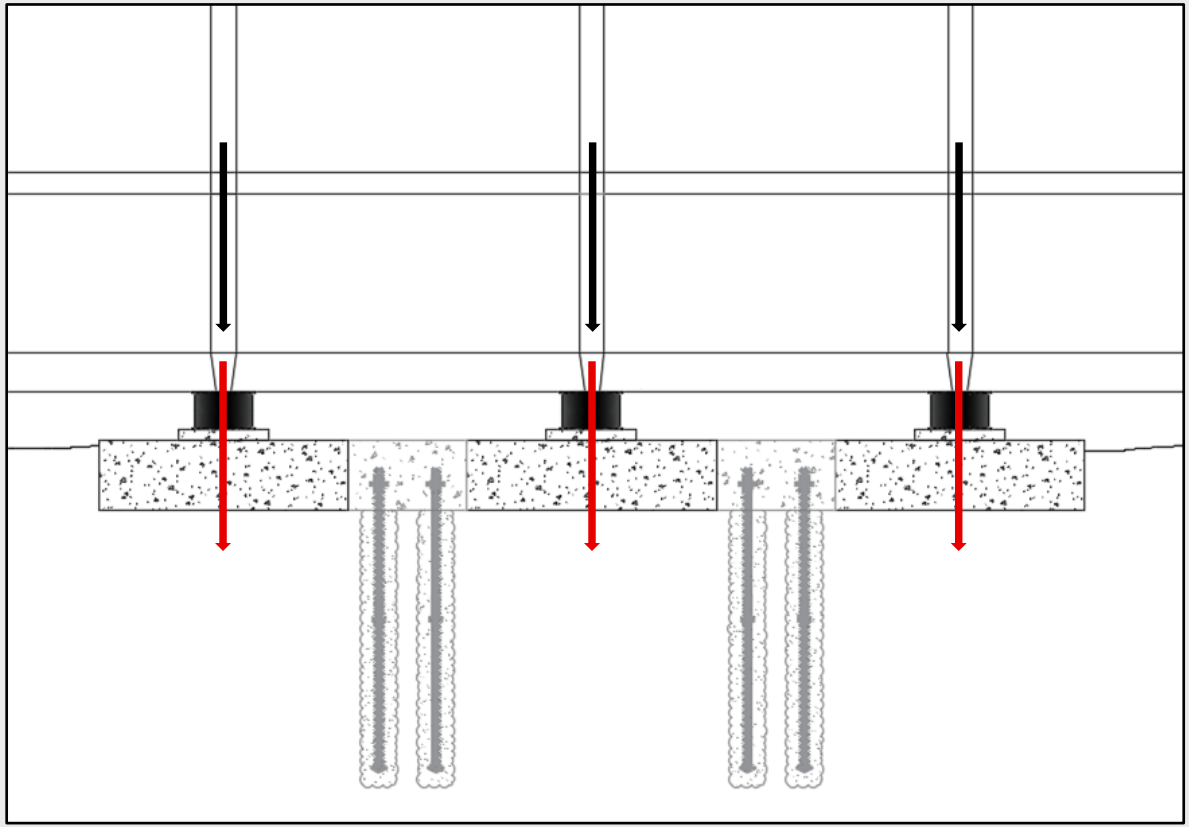
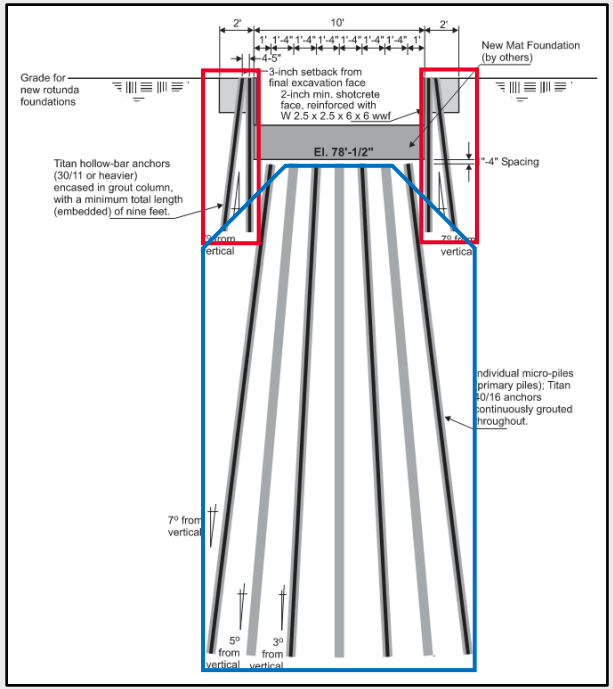
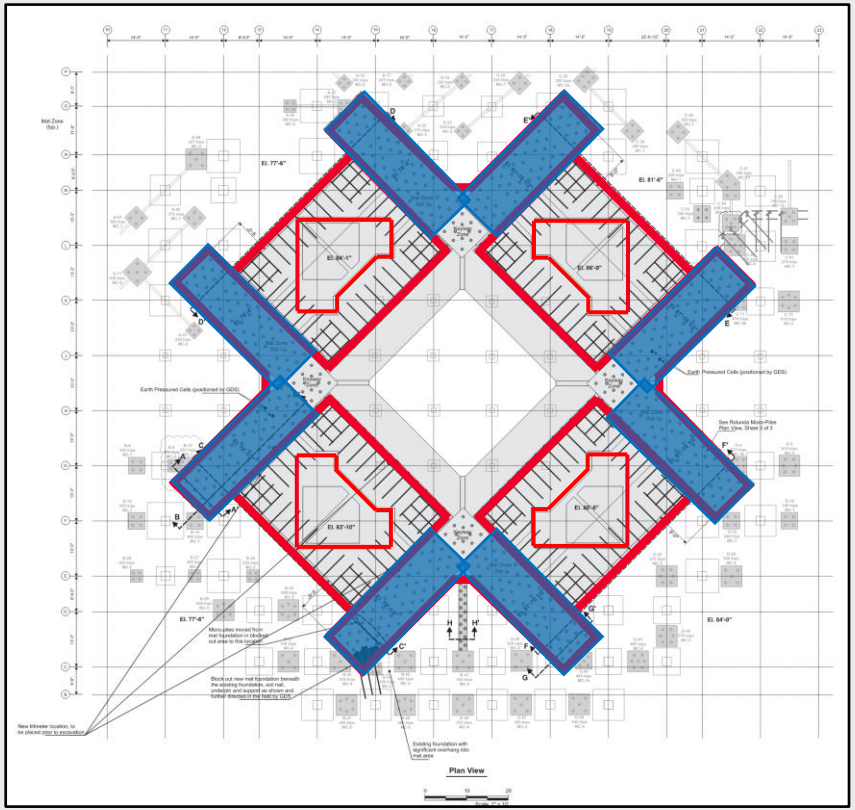


Utah State Capitol Seismic Retrofit

Utah State Capitol Seismic Retrofit Rotunda

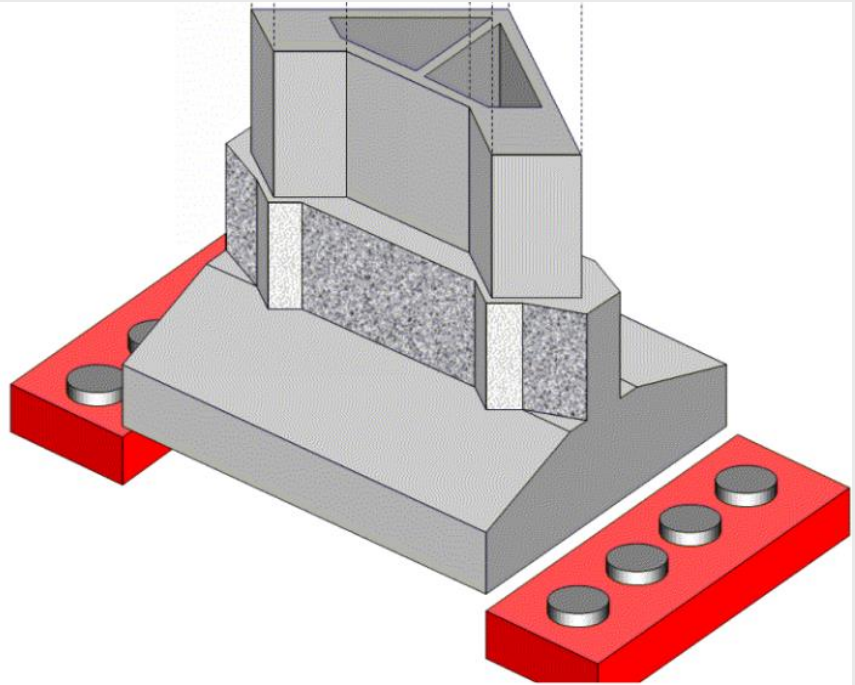
- Each rotunda pier carried close to 10,000kips
- Micropiles used for soil retainage to create pit for new pile cap
- Soil underneath new rotunda pile caps required 20kips per sqft of bearing capacity
- Micropiles used solely for ground improvement

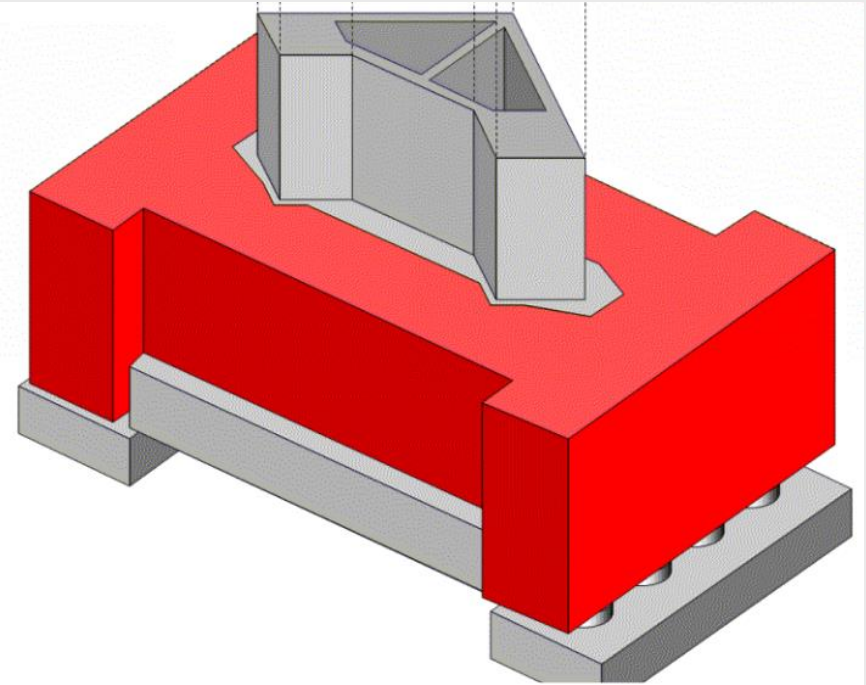




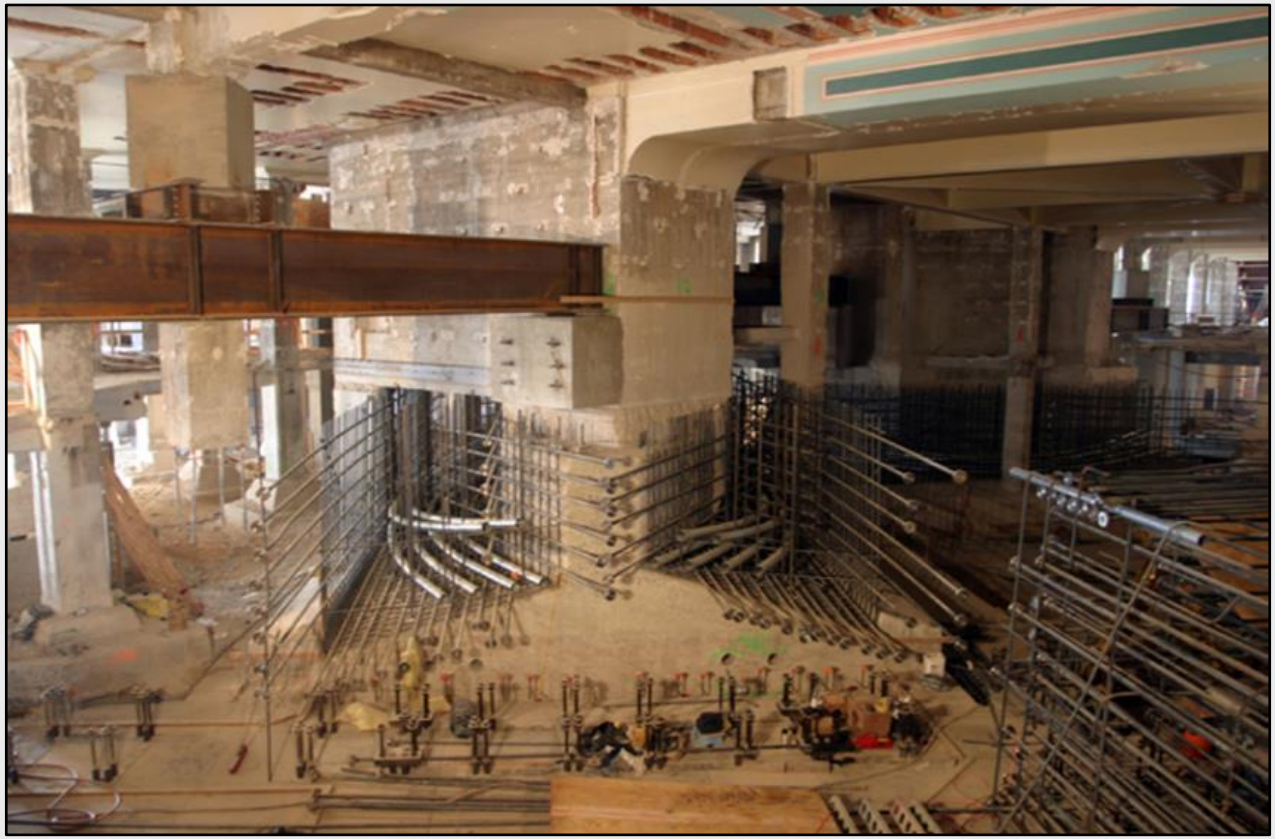
Utah State Capitol Seismic Retrofit Rotunda

Utah State Capitol Seismic Retrofit Rotunda

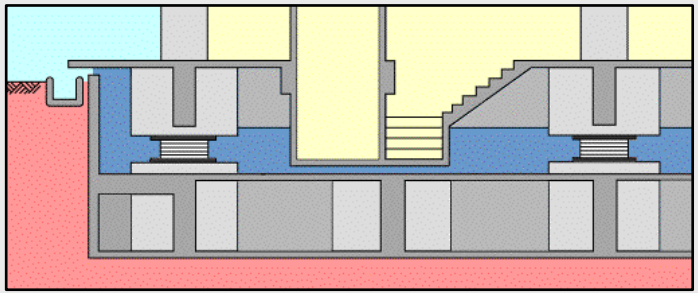


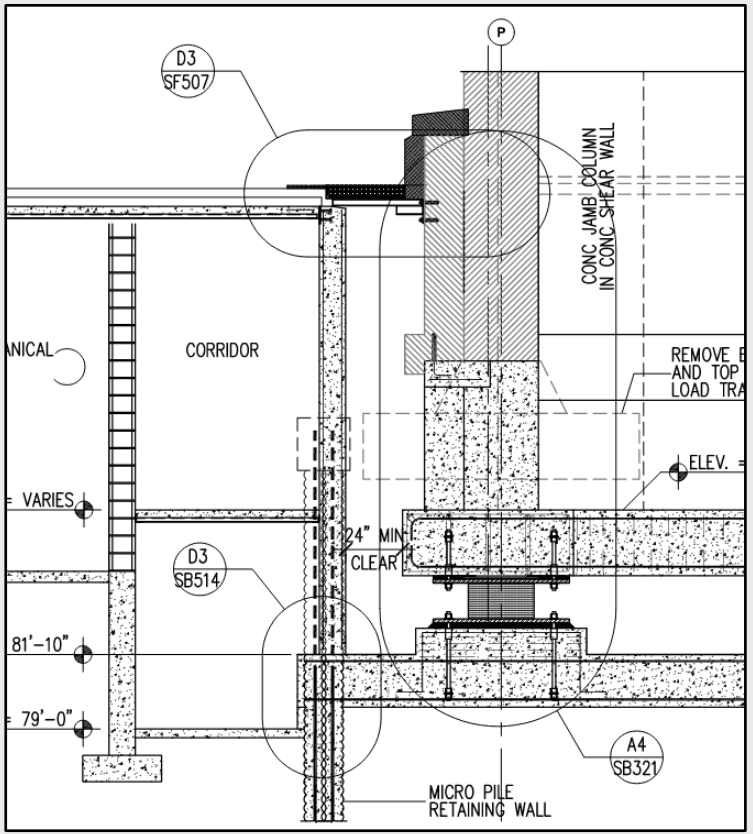


Utah State Capitol Seismic Retrofit Rotunda

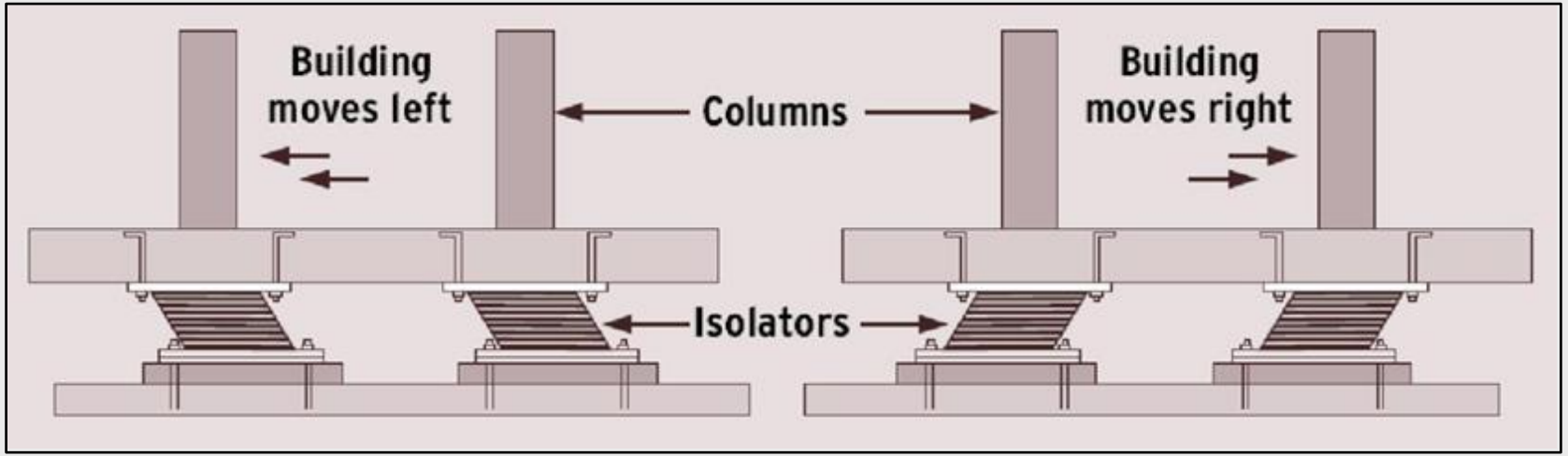


Utah State Capitol Seismic Retrofit





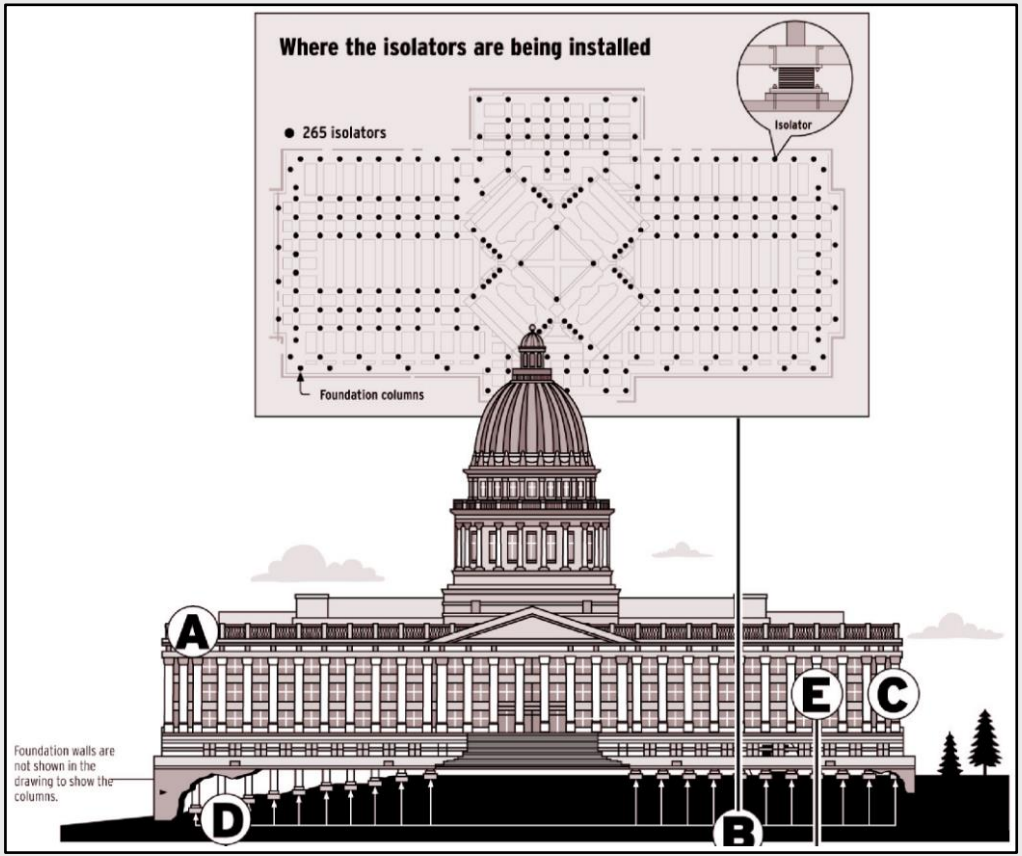
Summary



- During an earthquake, the structure will be able to move 2 feet in each direction for a total “swing” of 4 feet
- Horizontal seismic forces reduced by approximately 75% to 80%
- Structure will be able to withstand a 7.2 magnitude earthquake with minimal damage
- Large earthquake previously would have likely result in loss of the structure and loss of life

Summary

- Why Micropiles
  - Limited access
  - Low vibration
  - Tried jet grouting but deemed too messy under the building
  - Spoils and grout easier to control with hollow bar
  - Other methods to retrofit the building would have disturbed historical characteristics of the building
  - Not enough space to use traditional spread footings for required soil bearing pressure



Thank you for your attention

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*Photos and supporting information courtesy of Reaveley Engineers