

History of Seismic Design Codes

Building Code	Cs	% Increase from 1961
1961 UBC	0.100	0%
1976 UBC	0.105	5%
1988 UBC	0.254	154%
2000 IBC	0.308	208%
2006 IBC	0.298	198%
2018 IBC	0.288	188%

Assumptions: Ordinary Steel Braced Frame, Site Class D,
Location near Seattle, WA

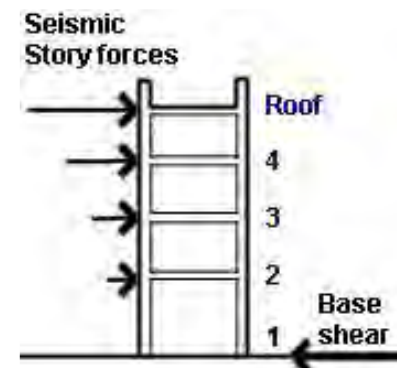
$$V = C_s * W$$

where:

V = Seismic Base Shear

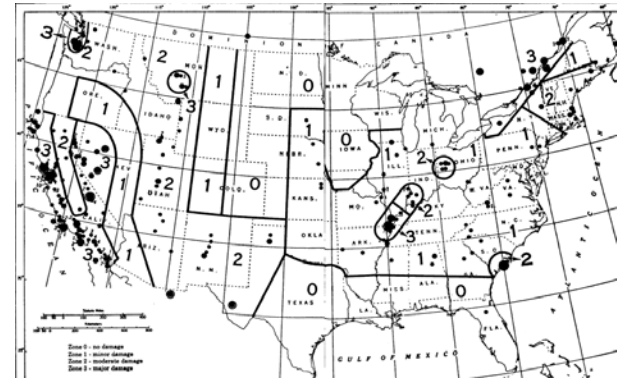
Cs = Seismic Response Coefficient

W = Building Weight

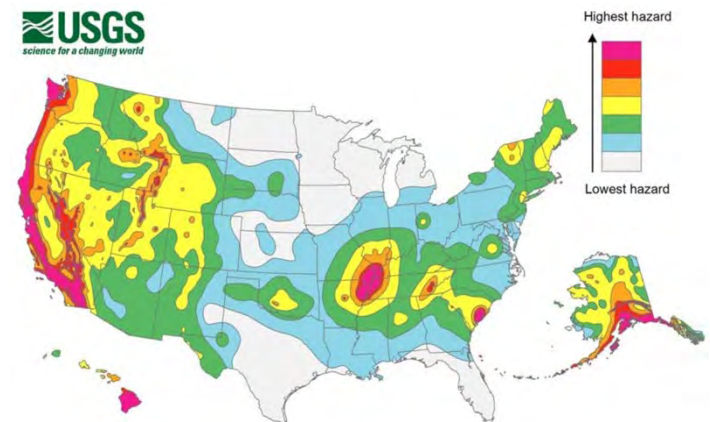


History Summary

- Prior to 1970's seismic design was very basic. Significant advancements were made from 1970-2000.
- Buildings constructed prior to 1988 may have been designed for significantly lower forces than would be required today (especially in liquefaction zones)
- Crustal and subduction zone events may have much greater intensities than the Nisqually earthquake did



Source: 1961 UBC



Source: USGS/2018 IBC



Common Causes of Earthquake Damage/Losses

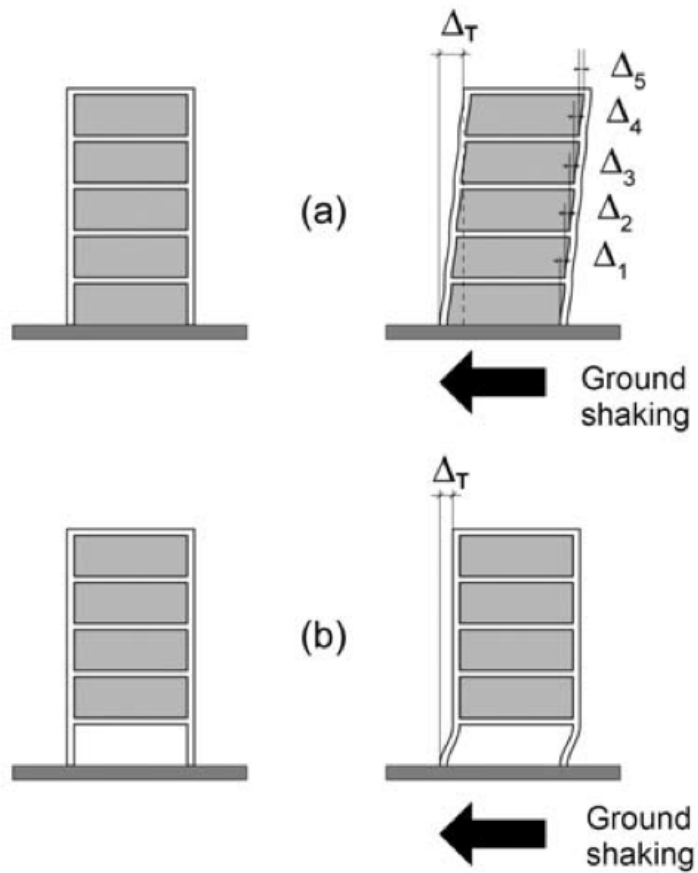
- Structural irregularities
- Structural deficiencies
- Non-structural damage
- Perpetual modifications
- Soil liquefaction & ground displacement
- Tsunamis



URM Building Damage in 2014 Napa Earthquake



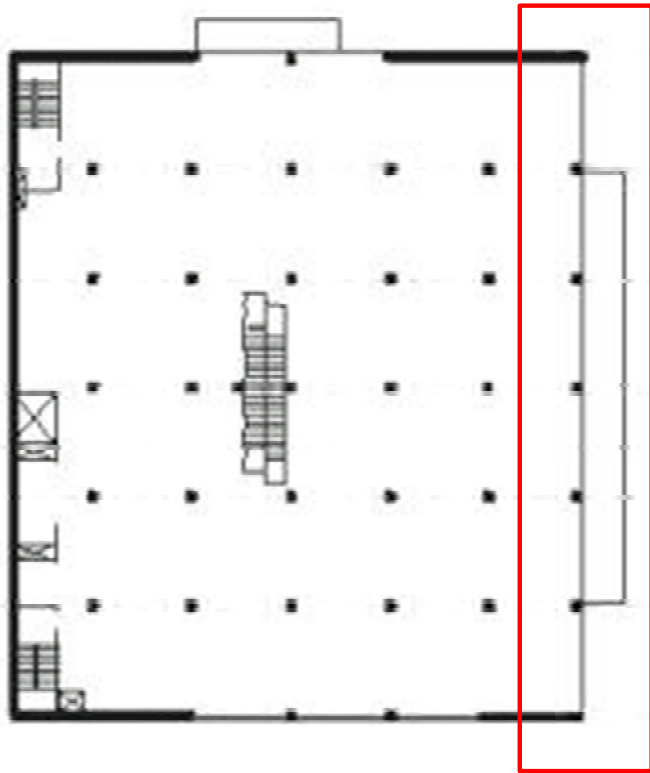
Structural Irregularities – Soft Story



1989 Loma Prieta Earthquake



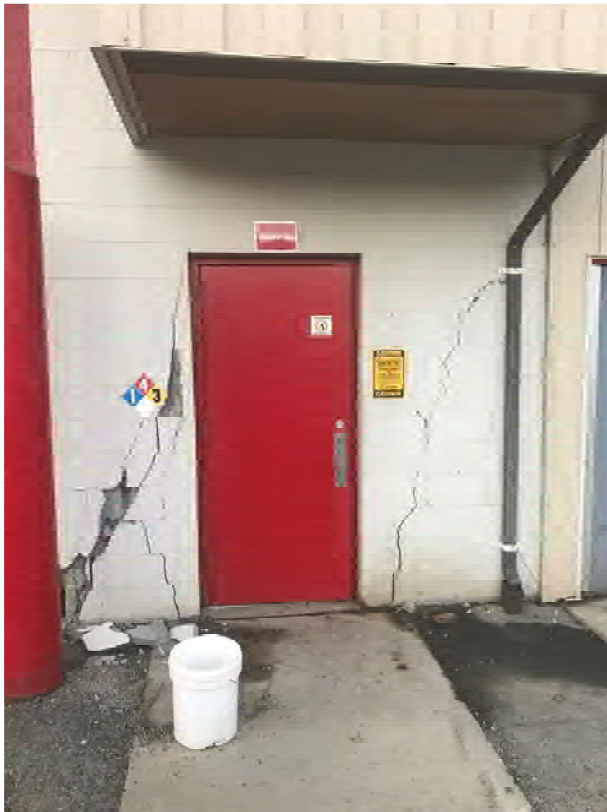
Structural Irregularities – Torsion



JC Penney's Building in 1964 Great Alaskan Earthquake



Structural Deficiencies – Un(der)reinforced Masonry



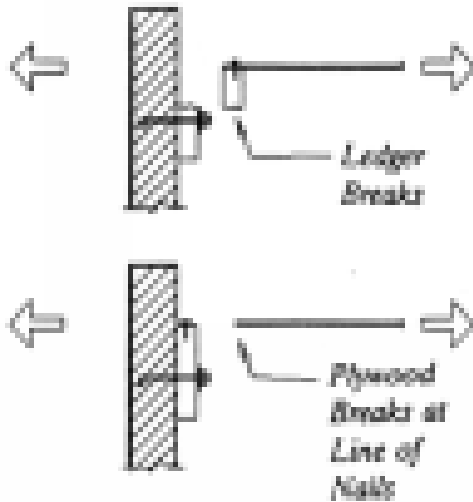
CMU Wall Cracking in 2018 Anchorage Earthquake



URM Building Damage in 2011 Christchurch, NZ Earthquake



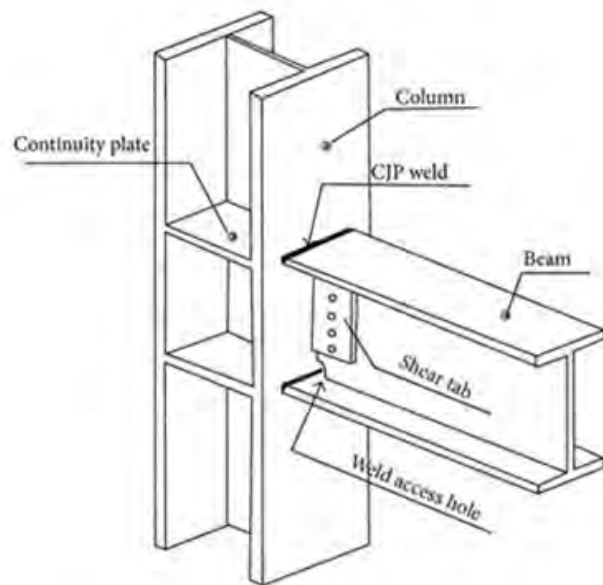
Structural Deficiencies – Wall Anchorage



Wall Anchorage Failure in 1994 Northridge Earthquake



Structural Deficiencies – Pre-Northridge MF



Pre-Northridge Moment Frame Connection Failure



Non-Structural Damage – Ceilings & Contents



Overturned Contents in 2018 Anchorage Earthquake



Seatac airport control tower (and temporary tower) following the 2001 Nisqually Earthquake



Non-Structural Damage – Water & Fire Lines



Water damage from domestic water line break in 2018 Anchorage Earthquake



Water damage in 2018 Anchorage Earthquake



Non-Structural Damage - Racking



Storage Racks in 1994 Northridge Earthquake



Wine Barrels in 2014 Napa Earthquake



Non-Structural Damage – Equipment



Damage from molten glass tank overturning in Japan



Overturned motor control center in 2019 China Lake Earthquake



Non-Structural Damage – Equipment



Unanchored boiler shifted and broke natural gas line in 2018 Anchorage Earthquake



Non-Structural Damage – Utilities



Broken water line in 2018 Anchorage Earthquake



Fire in 1994 Northridge Earthquake due to broken gas line

