

Performance of Buildings and Nonstructural Components in the South Napa Earthquake

John Gillengerten, S.E.



FEMA

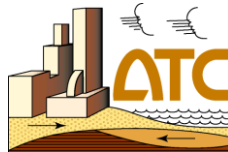


FEMA P-1024

- FEMA/ATC special project to gather information on the performance of buildings and nonstructural components in the South Napa earthquake
- Project Team:
 - Michael Mahoney, FEMA Project Officer
 - Maryann Phipps and John Gillengerten, Technical co-Directors
 - Ayse Hortacsu, ATC Project Manager
 - Many other contributors in specific areas of expertise

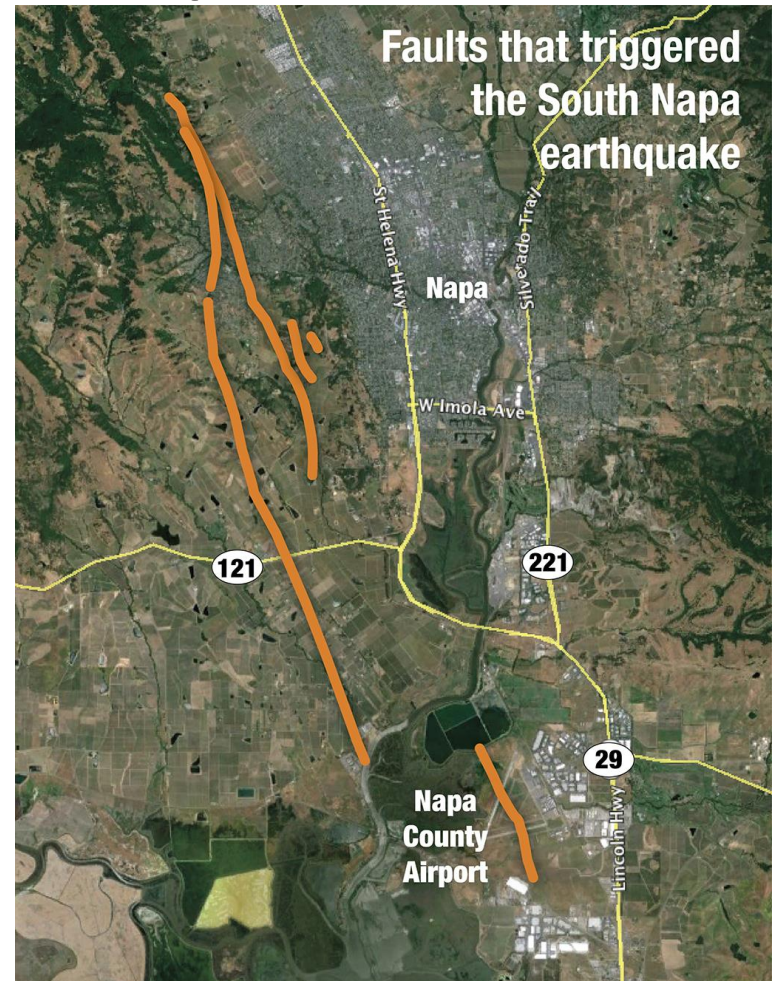


FEMA



South Napa Earthquake

- M6.0, depth 11.7km on the West Napa fault
- Surface rupture length 14km, located along the west side of Napa Valley
- The last earthquake on this fault was a M5.1 in 2000, located 10 miles NW of Napa, near Yountville



FEMA



South Napa Earthquake

- Time of event, 3:20am on August 24, resulted in minimal casualties
- Only one death reported related to the South Napa earthquake
 - A 65-year-old woman struck by a television who refused hospital aid and died of an intracranial hemorrhage two weeks later.
- Once again, we were very lucky - 12 hours earlier, the streets were full of people attending a downtown street festival



FEMA



FEMA P-1024



- Effort based on ATC-38 program:
 - Ground motion instrument site selected
 - Every building within a 1,000 ft. radius is investigated
- Compare building performance against a known ground motion value
- Study centered on USGS seismometer N016 – peak acceleration = 0.65g



FEMA

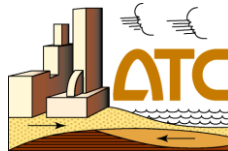


FEMA P-1024 Scope

- Performance of Buildings
 - Newer buildings (Post-1998)
 - Non-URM, Pre-1998
 - Retrofitted and un-retrofitted URM
 - Outside the instrument study area: Healthcare, residential, manufactured housing, schools, healthcare, wineries
- Performance on Nonstructural Components



FEMA

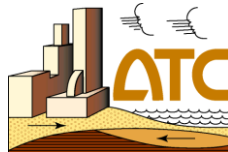


Performance Surveys

- 68 buildings surveyed within 1,000 ft of Station N016
 - Interior and exterior surveys for 50 of the buildings
 - exterior only surveys for 18 buildings
 - 77% of buildings constructed in 1950 or earlier
 - Median age of buildings is 84 years
 - URM buildings make up 40% of the buildings



FEMA

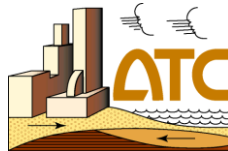


Newer Buildings

- Buildings constructed to recent codes generally performed well structurally
- Some newer buildings suffered significant nonstructural damage



FEMA



Pre-1998 Buildings

- The vast majority of older, non-URM structures also performed well structurally
- Known vulnerabilities, such as poor wall to roof connections, did result in significant damage and loss of use



FEMA

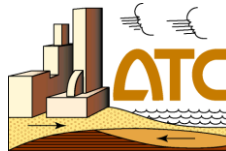


Unreinforced Masonry Buildings

- A 1986 California law requires localities to establish a seismic retrofit program for URM buildings.
- Napa URM retrofit ordinance
 - Passed in 2006, mandatory retrofit within 3 years
 - Objective: “to reduce the risk of death or injury”
 - Of the 26 URM buildings within 1,000 foot of Station N016, 19 had been retrofitted

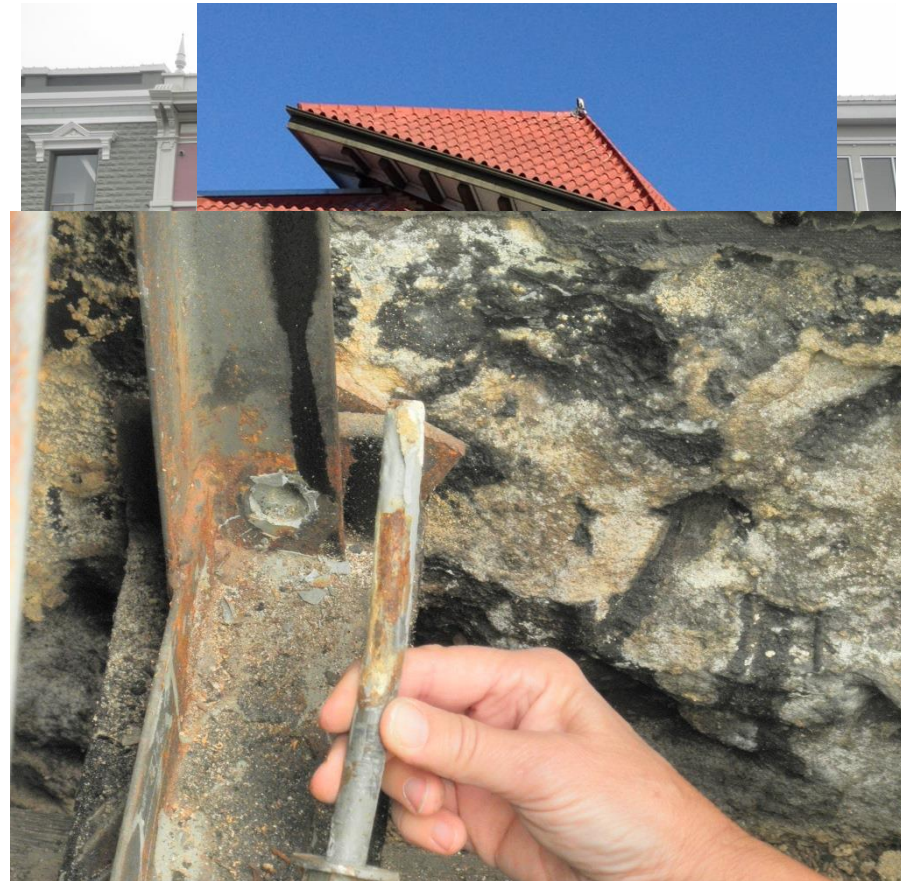


FEMA

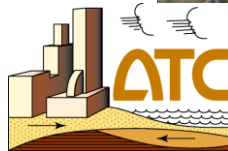


Retrofitted Unreinforced Masonry Buildings

- 13 buildings suffered no structural damage or the damage was deemed insignificant
- 3 buildings suffered minor damage, 1 building moderate damage, 2 were heavily damaged
- Some exterior masonry loosened or fell from three of the damaged buildings

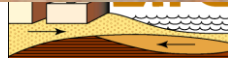


FEMA



Un-retrofitted URM

- 3 in
- 1
- 1
- 2 da
- So
- sig

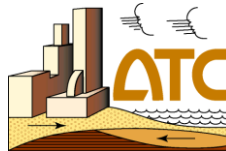


Healthcare Facilities

- 5 hospitals and 13 skilled nursing facilities located between 4 and 10 miles from the epicenter
- Wide range of structural types, some buildings over 50 years old
- No facility suffered serious damage
- Nonstructural damage did interfere with the delivery of some healthcare services



FEMA



Residential Construction

- 61 of 116 buildings in Napa posted UNSAFE were residential buildings
- Damage concentrated heavily on two key deficiencies: masonry chimneys and unbraced cripple walls



FEMA



Manufactured Homes

- Since S lateral require manufa Californ
- Majorit Napa w bracing
- Braced homes the san



FEMA

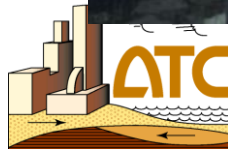


Nonstructural Components

- Fire sprinkler failures
 - Interaction between heads and piping or other components
 - In most cases, the water could not be turned off
 - Serious flooding and water damage in some buildings
 - Pipe and anchor failures

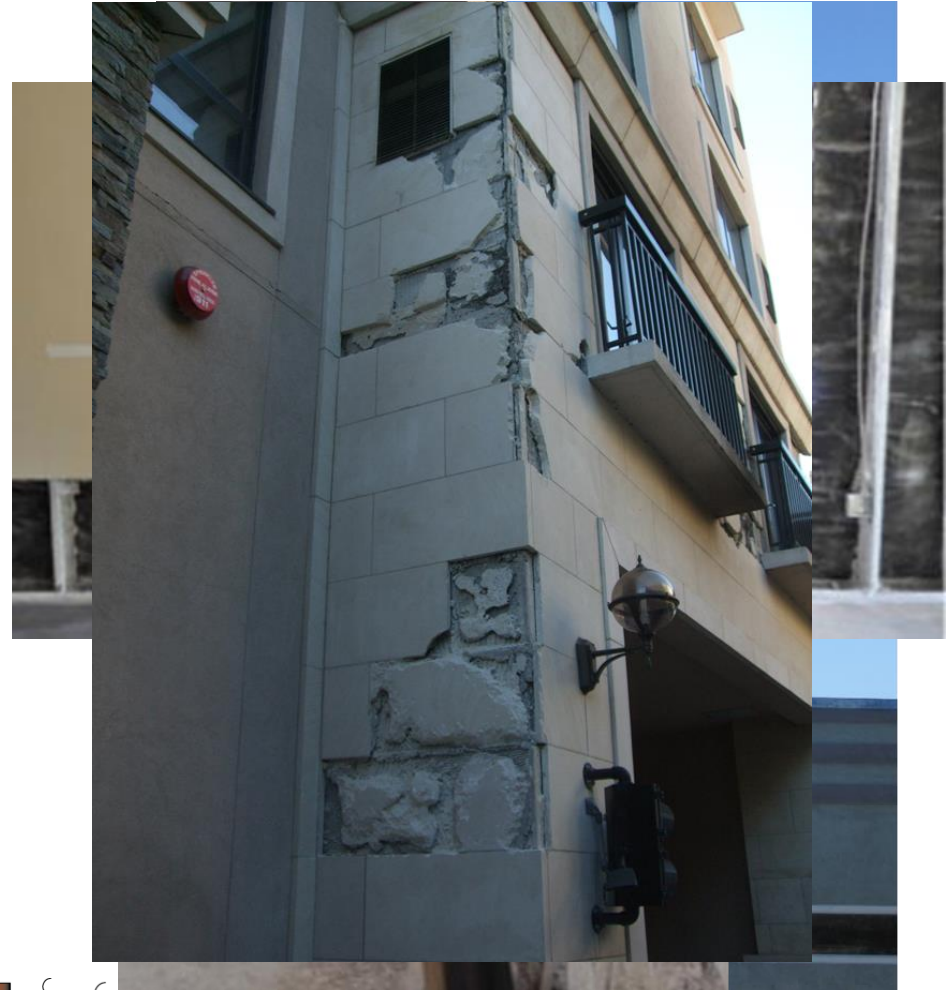


FEMA



Nonstructural Components

- Light curtain wall systems
 - Some modern structures suffering substantial cracking and loss of veneer
 - In at least one case, the curtain wall system appears to have been designed without a mechanism to accommodate interstory drift without damage
 - The performance of adhered veneer was directly related to the performance of the substrate and the strength and condition of the adhesive material

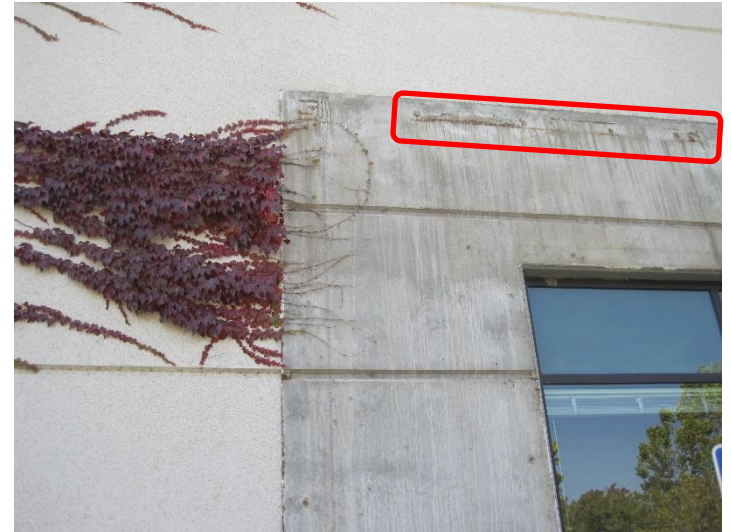


FEMA

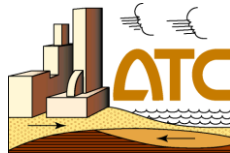


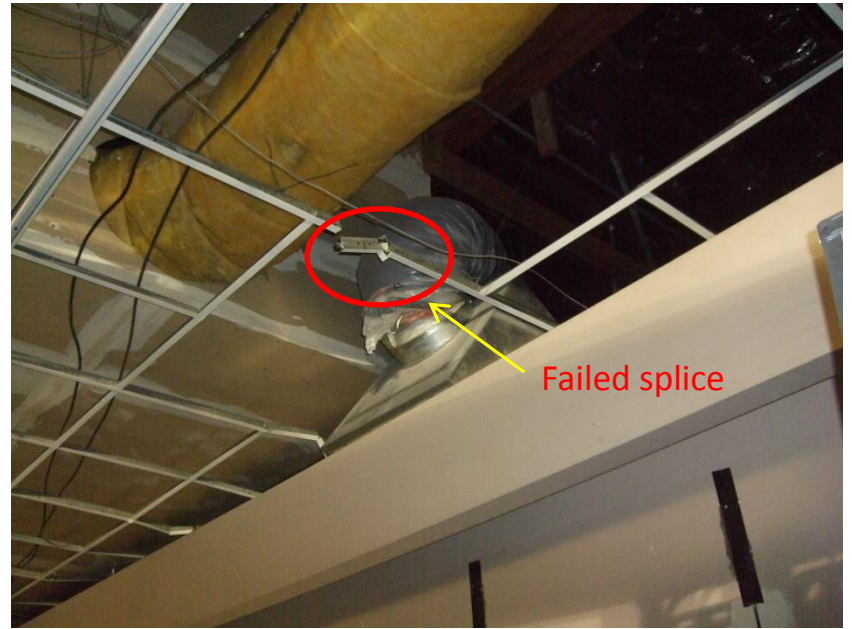
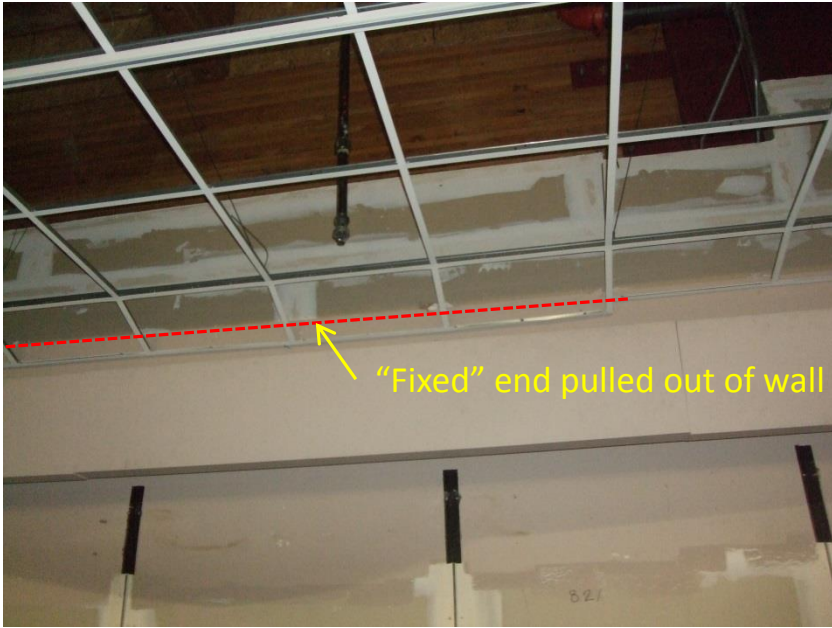
source: Lauren Biscombe



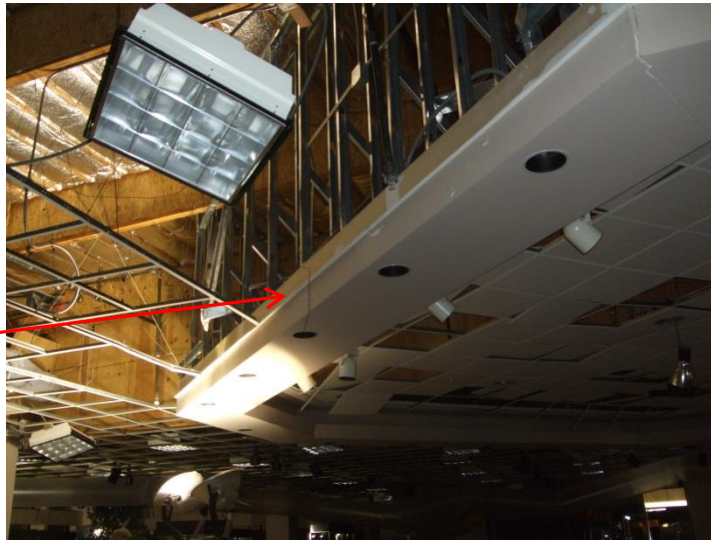


FEMA





"Free" end dislodged, grid dropped



FEMA

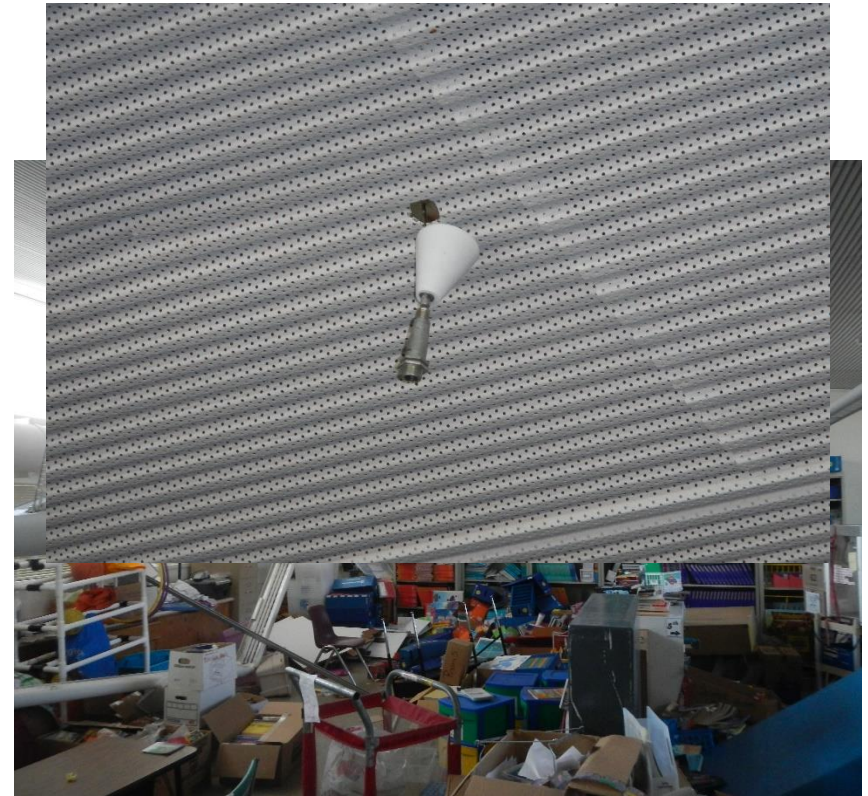


Wine Industry



Schools

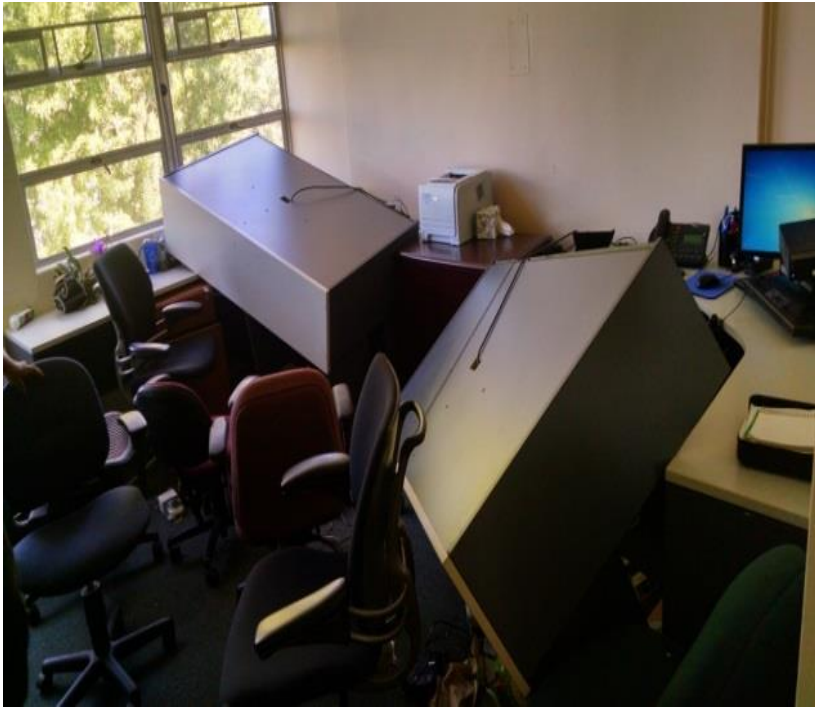
- 31 public school sites in Napa County
- One or two-story buildings of wood frame or reinforced masonry construction
- Little or no structural damage to any of the schools, but...
 - Repairs estimated at \$8 million
 - Loss of contents \$9 million



FEMA



Contents



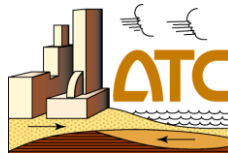
Hospital offices



Napa County High School



FEMA



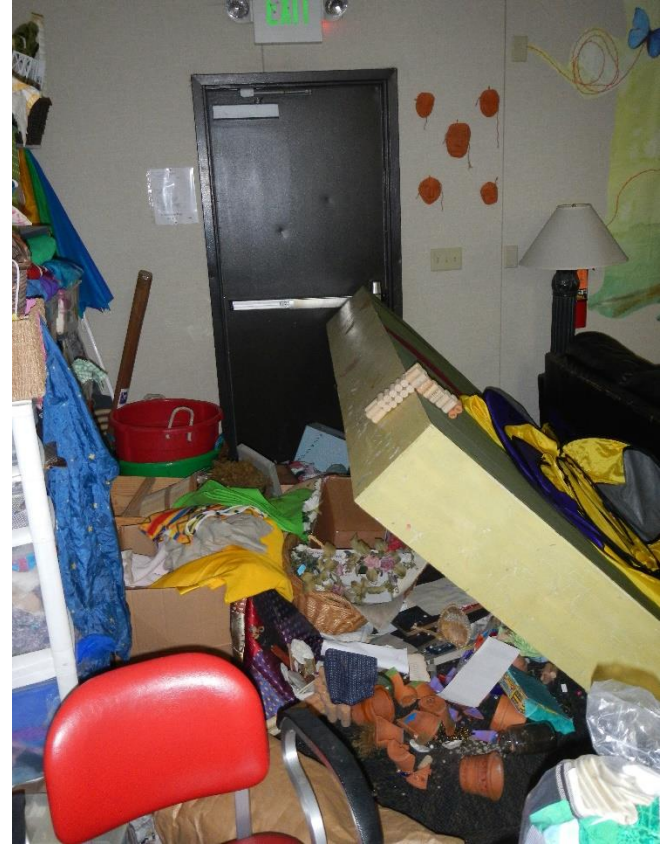
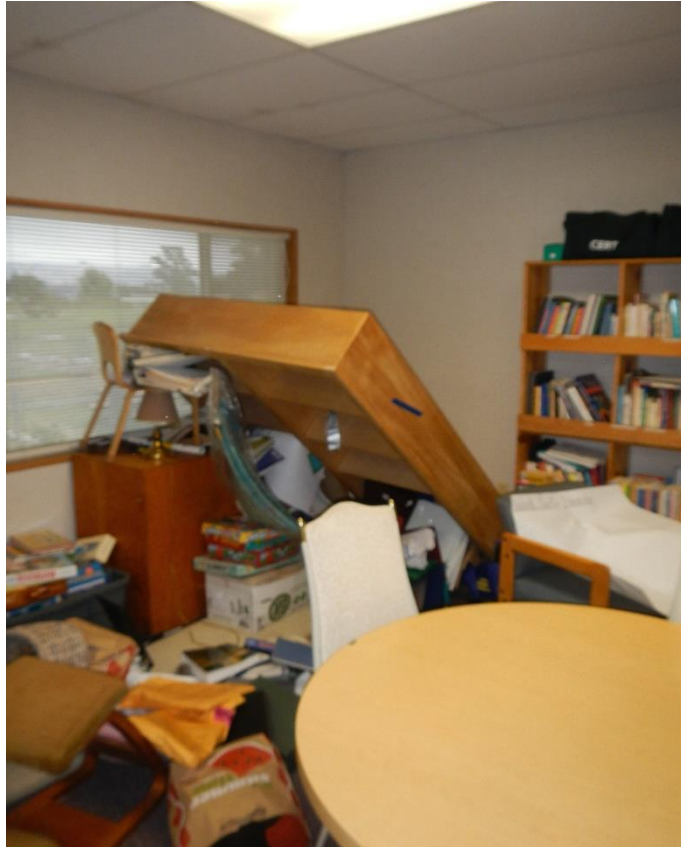
Contents



FEMA



“Furniture”



Stone Bridge School



FEMA

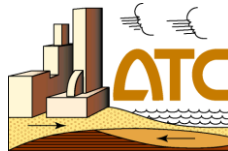


South Napa EQ Observations

- Seismically retrofitted older buildings (URM's):
 - Test of URM seismic retrofit strategies
 - Performed well, with a few notable exceptions.
- Un-retrofitted URM buildings did not perform as well
- Partial wall collapse in one building resulted in five other buildings being red-tagged
- Newer construction performed well structurally



FEMA

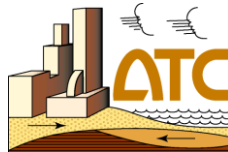


South Napa EQ Observations

- Masonry chimneys continue to be a serious problem and threat in residential construction
- Unbraced cripple wall foundations did not perform well
- Buildings with cripple walls retrofitted for flood performed well
- Lateral bracing systems for manufactured housing need further review and development



FEMA



South Napa EQ Observations

- Nonstructural damage is typically the largest contributor to financial losses (>80%).
 - We are now very good at life safety.
 - We are still not very good at damage reduction
- Damage to nonstructural components can cause injury or death.
- Fire sprinkler piping damage and resultant water damage greater than expected.



FEMA

