

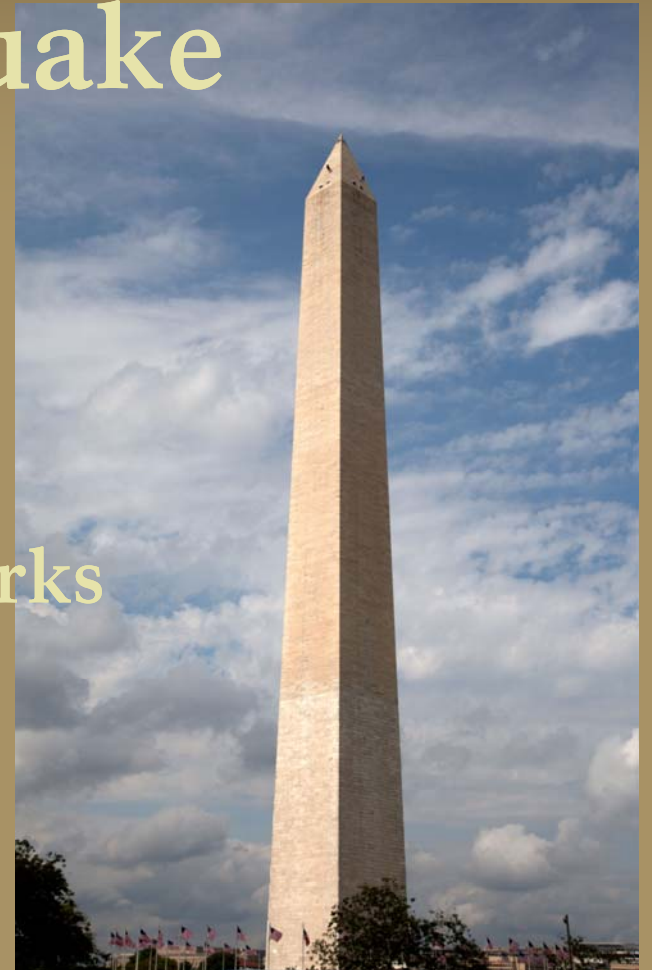
National Park Service  
U.S. Department of the Interior



# August 2011 Earthquake Damage Repair

Compliance Review -  
Denver Service Center &  
National Mall and Memorial Parks  
Washington, D.C.

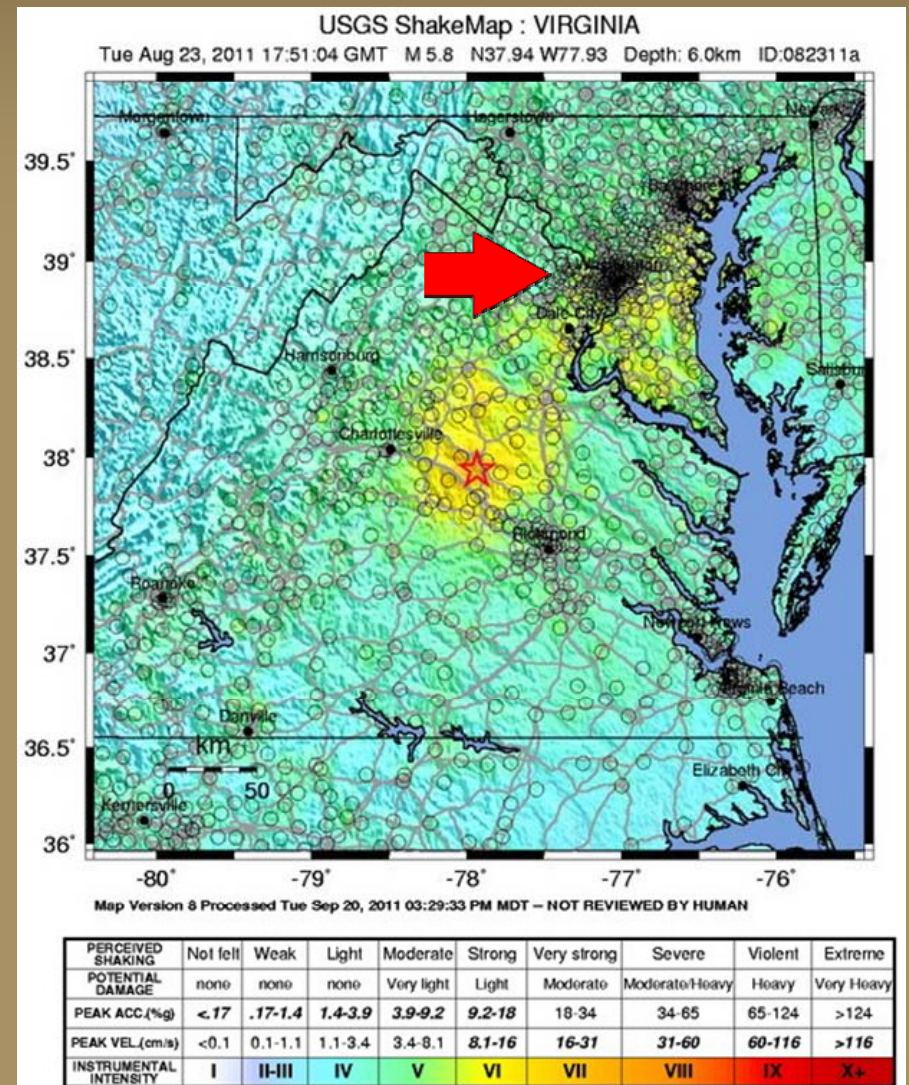
July 2012



EXPERIENCE YOUR AMERICA

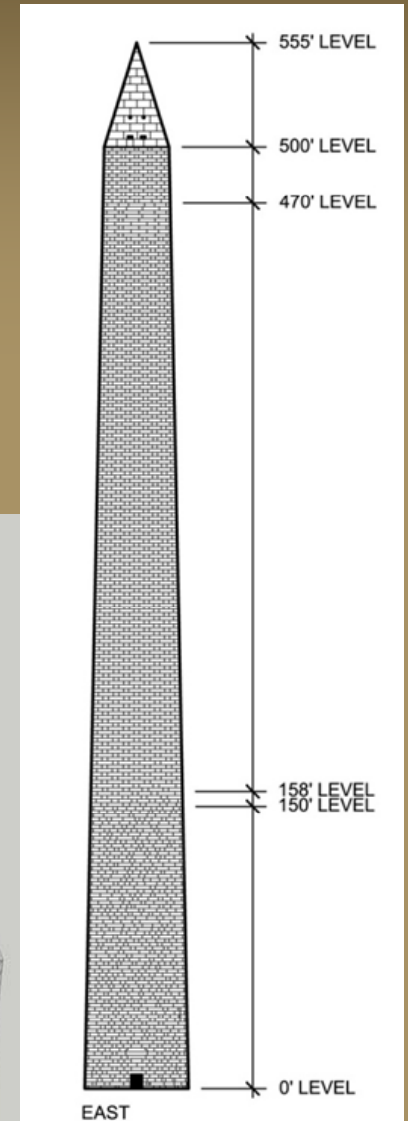
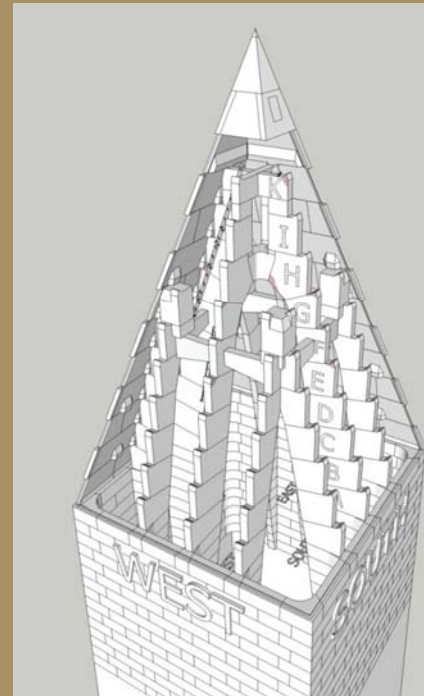
# Washington DC Earthquake

- August 23, 2011, a 5.8 scale earthquake struck the area near Mineral, Virginia, resulting in strong seismic ground motion in the Washington, D.C. metro area
- The Earthquake caused damage to the Washington Monument and other structures in DC, 84 miles distant



# Washington Monument

- One of the most recognizable and symbolic structures in the nation – Listed on the National Register of Historic Places
- 555'- 5 1/8" stone obelisk  
Freestanding, load-bearing masonry structure
- Constructed in two phases between 1848-1884

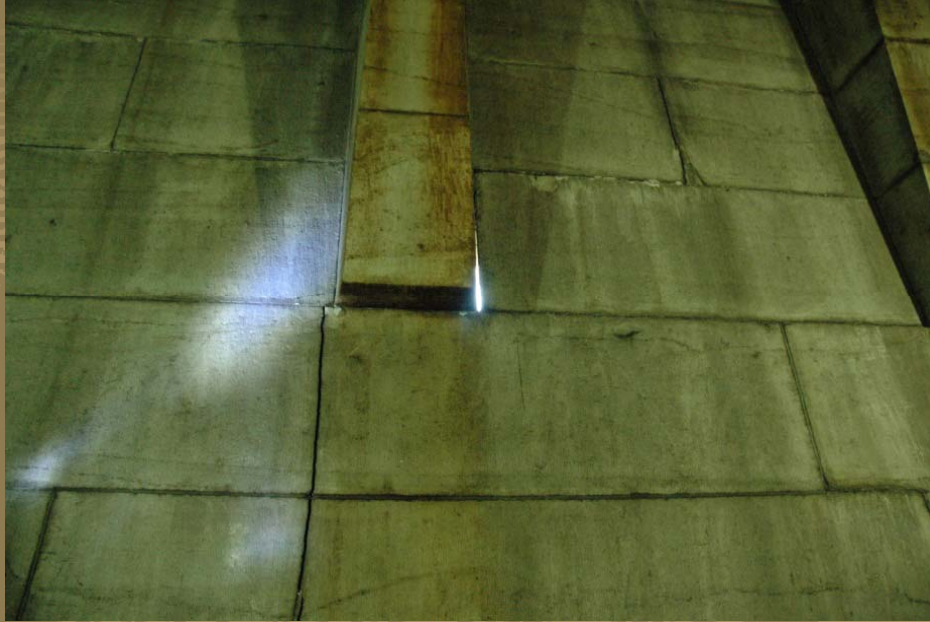




# Earthquake Damage, August 2011



# Earthquake Damage, August 2011





# Damage Assessments

## ■ Immediate Response:

- NPS & A/E team at site 7am August 25th; monument examined and found structurally sound, but w/ visible damage in Pyramidion
- A/E "Difficult Access Team" (DAT) completed emergency water-proofing of cracks & removed loose stone in interior at Visitor Viewing levels
- Elevator damaged, but was partially repaired to operate in "Test" mode to support A/E team assessments & NPS access



# Damage Assessments

## ■ Follow-on Response:

- Detailed exterior survey with A/E "DAT" conducted Sept. 23 – Oct. 5, 2011; Damaged areas mapped based on documentation from 1999 restoration
- Heaviest damage at the ribbed portion @ Elev. 475' – 530'
- Exterior fall hazards removed from monument Pyramidion and shaft



# Damage Assessments

- **Pyramidion:**

Cracking of marble panels, spalling, cracked tie beams, rib bearing haunches, and displaced rib stones

- **0' – 500' Monument Shaft:**

Joint mortar displacement (interior/exterior), cracks and excessive water infiltration

- **Monument Elevator:**

Twisted counterweight frame & rails, stretched cables





# Damage Assessments



# Damage Assessments





# Damage Assessments



Exterior corner spall held in place by lead joint tee and lightning protection system.

Also seen is the damaged (out-of-alignment) lightning protection system.

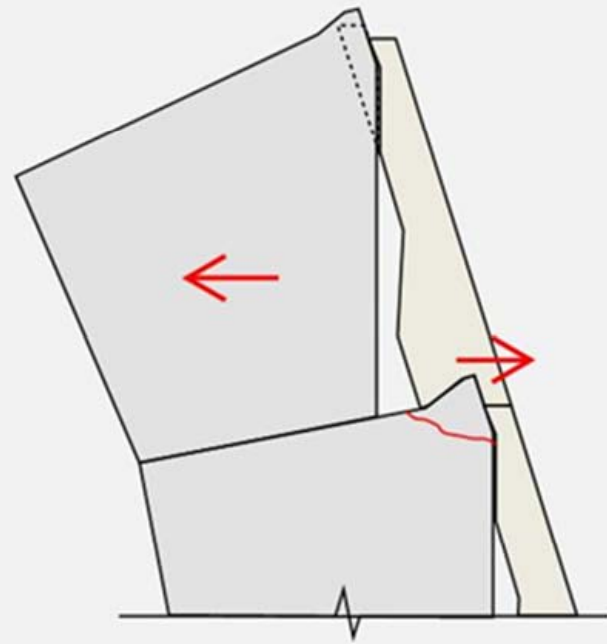
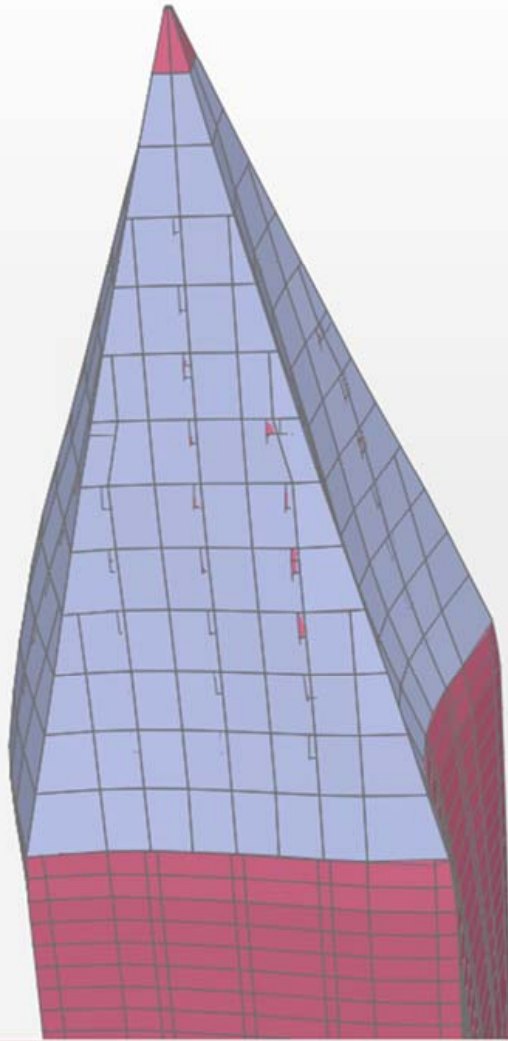


# Damage Assessments

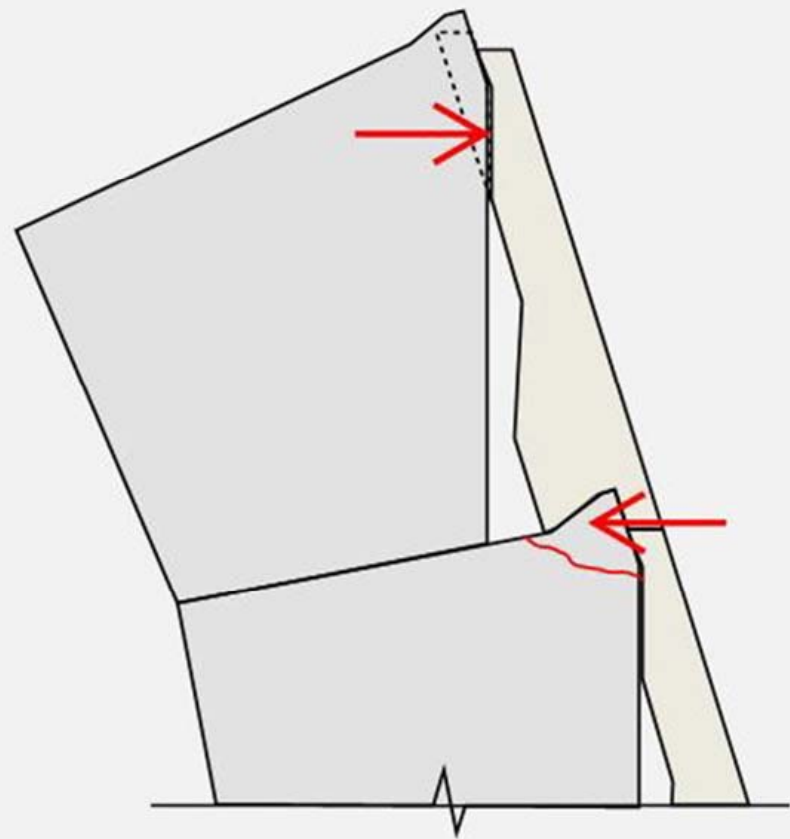
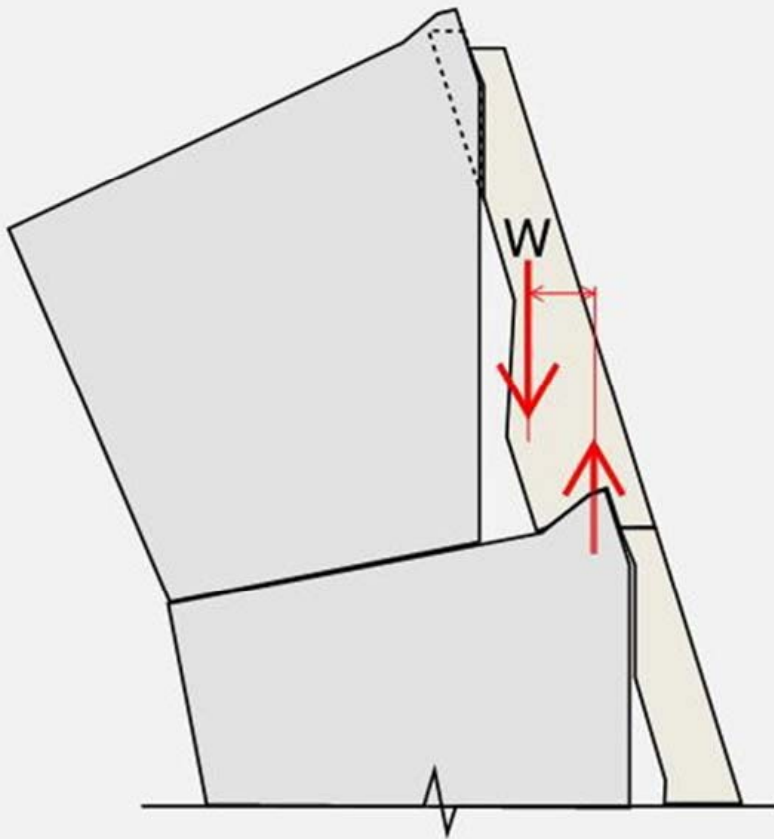
Cracked – through pyramidion panels and haunches.



# Seismic Induced Stresses

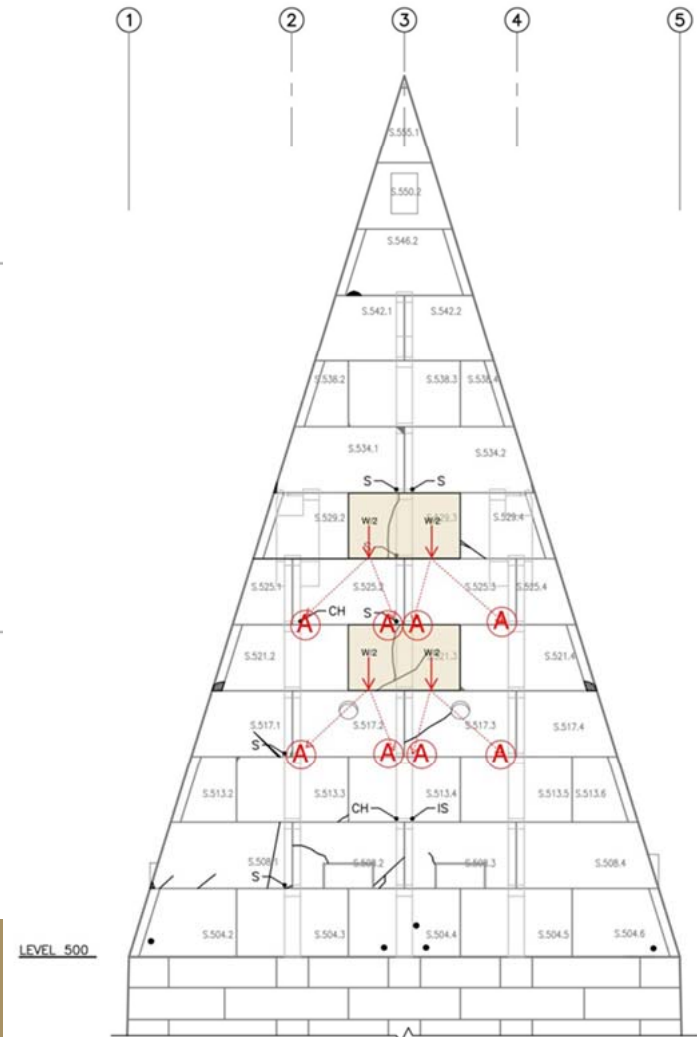
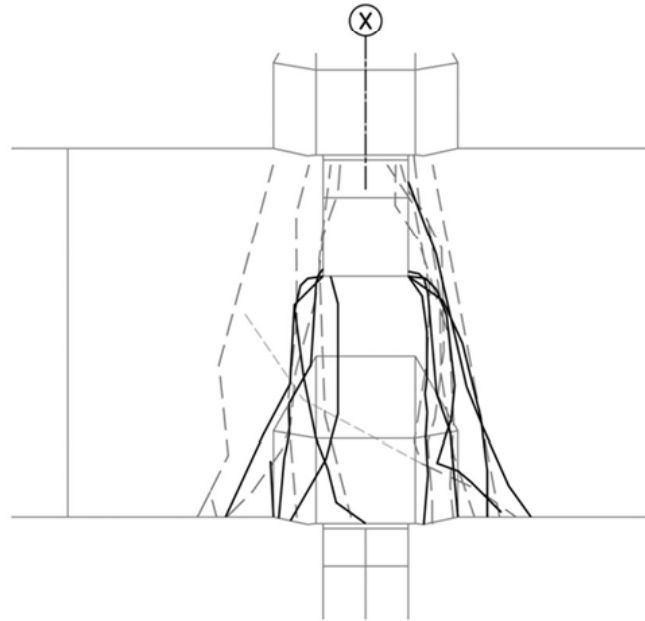
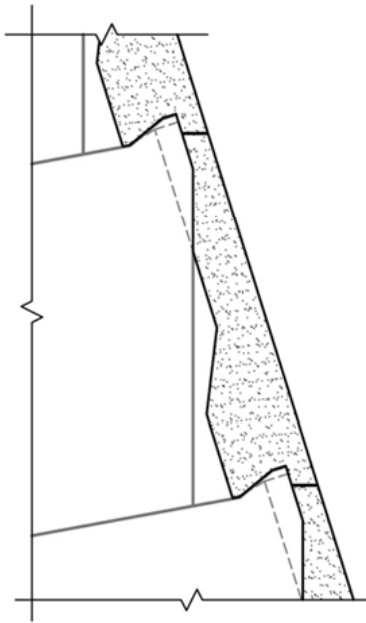


# Panel Forces on Rib Tips





# Cracked Panel Load Analysis



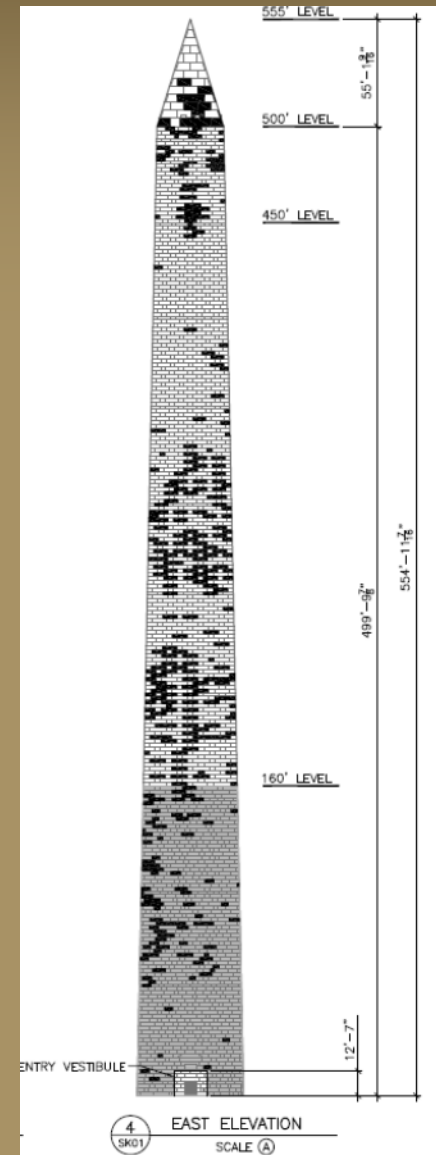
PANEL ANCHORAGE CRITERIA  
BASED ON CRACKED PANELS

# Proposed Monument Repairs

Based on the damage and engineering analysis, the repair plan was developed to replace in kind damaged masonry of the Monument.

Where needed, masonry anchors will be installed to strengthen damaged structural stone.

Elevation view of damaged exterior panels that require repair.



# Proposed Monument Repairs

## ■ Pyramidion & Monument shaft:

### Exterior

- Removal of loose stone fragments
- Securing loose pieces of stone w/ small drilled anchors
- Seal cracked panels via sealant and/or epoxy injection
- Stone patching via Dutchman and/or mortar patches
- Repointing mortar joints
- Low pressure water rinse
- Remove/reinstall lightning protection system



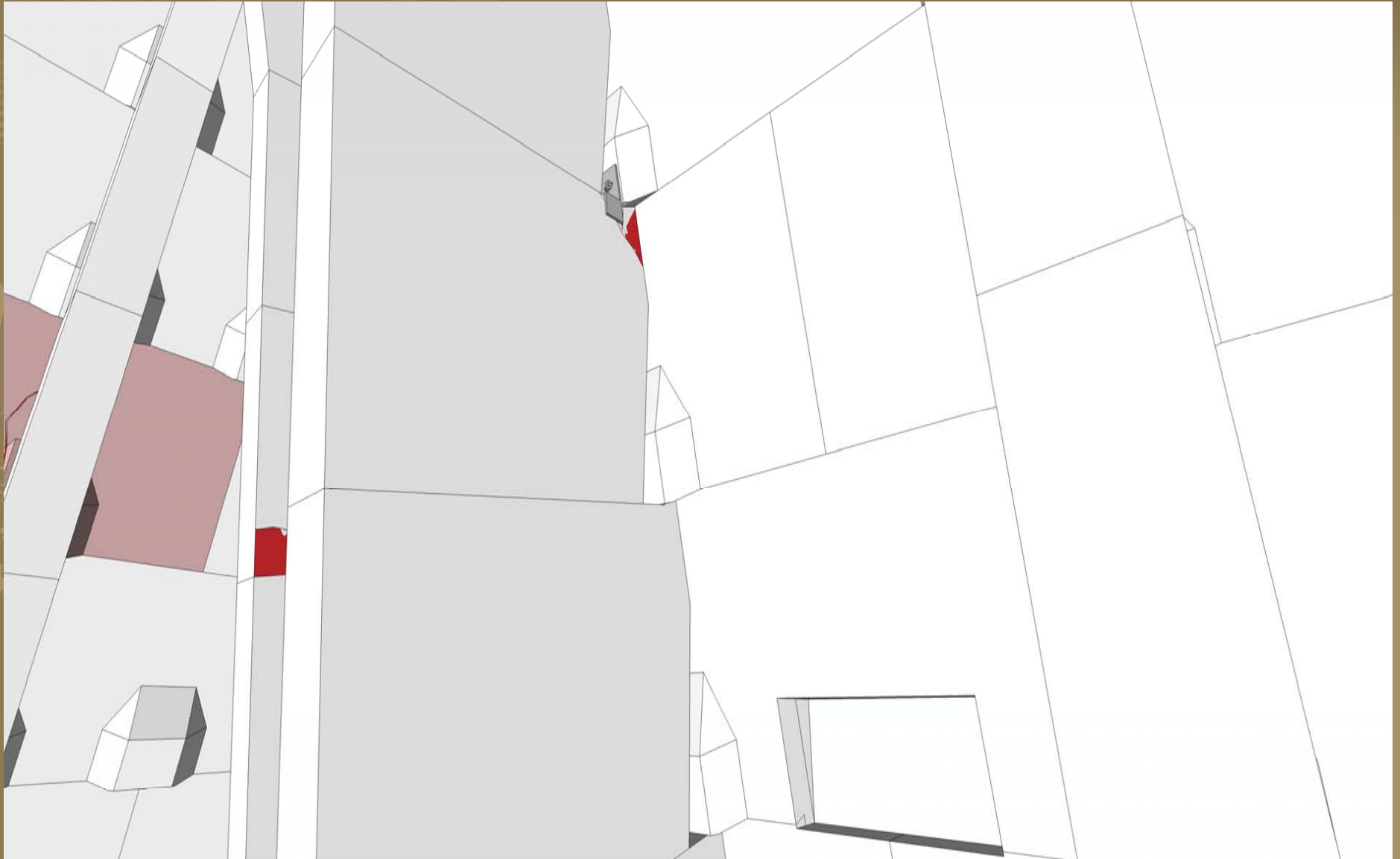
# Proposed Monument Repairs

## ■ Pyramidion & Monument shaft:

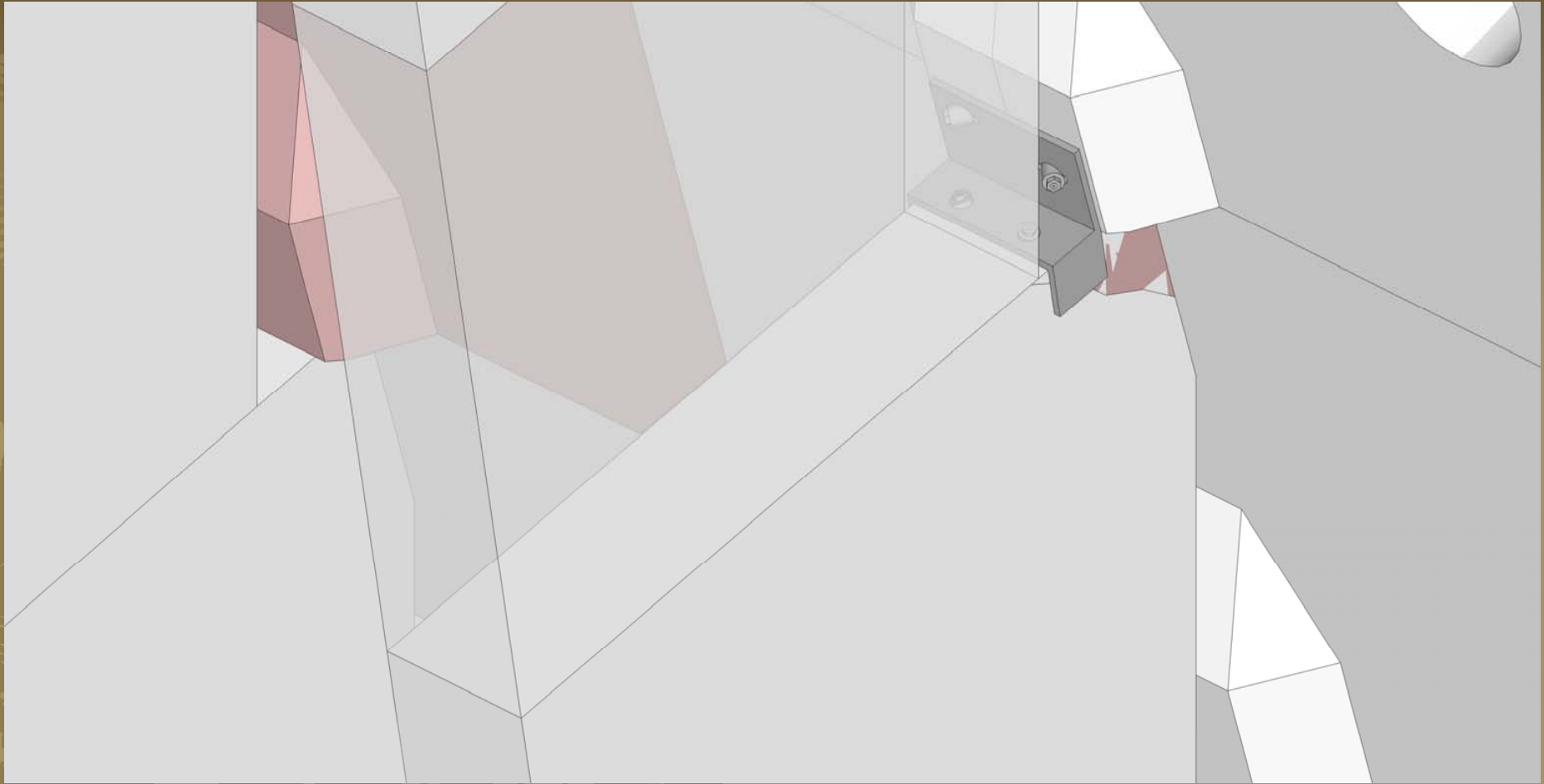
### Interior

- Structural repair of cracked stone panels
- Structural repair of Rib Bearing Haunches
- Structural repair of cracked Tie Beams
- Structural repair of displaced Rib Stones
- Seal cracked panels via sealant and/or epoxy injection
- Repointing mortar joints

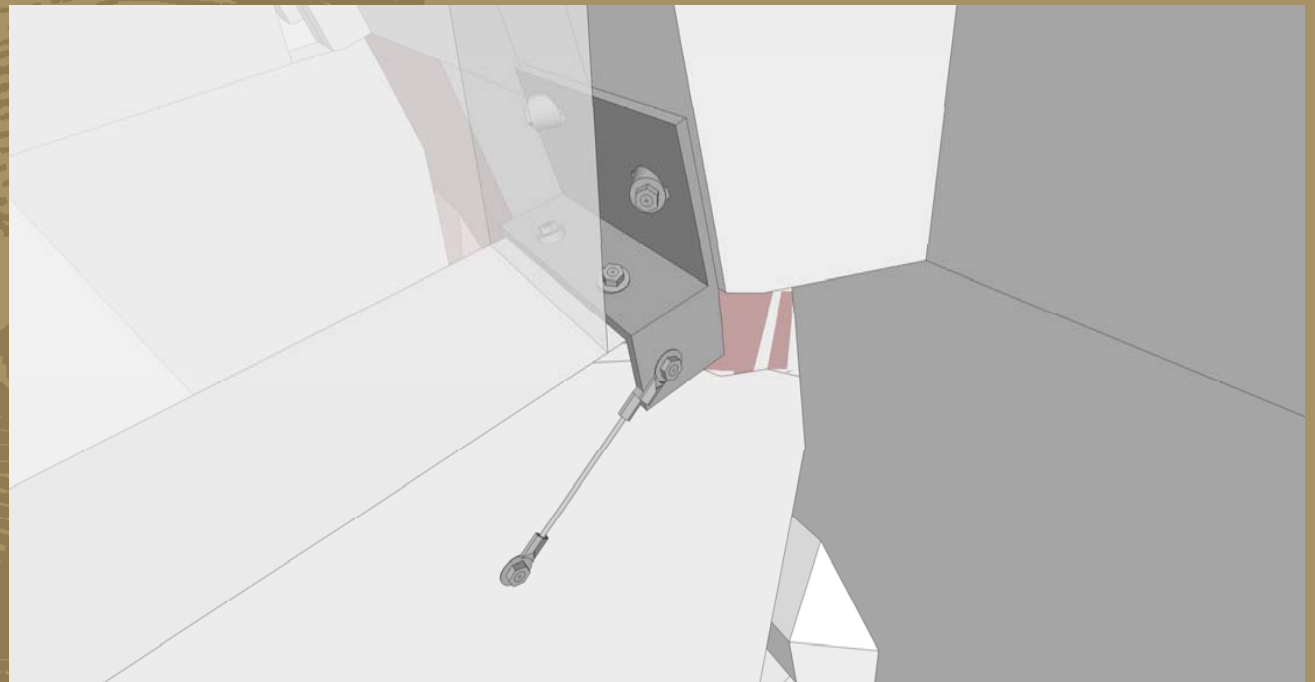
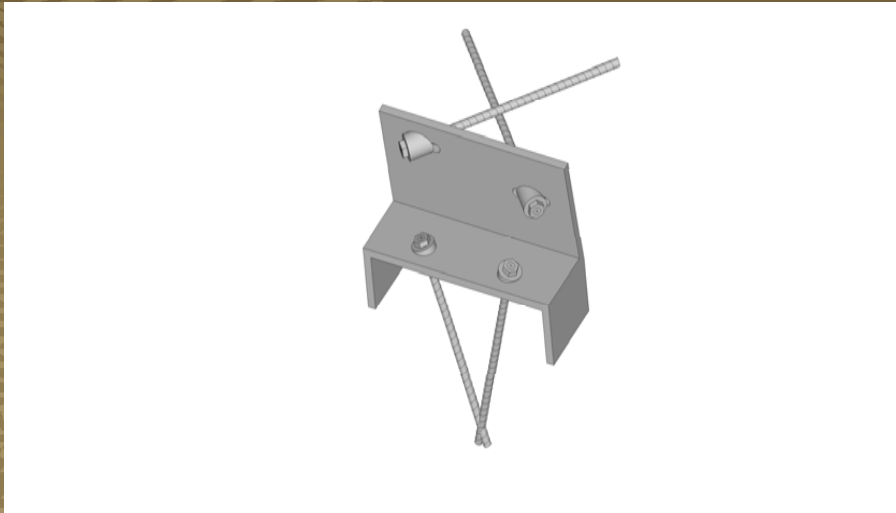
# Proposed Anchor Repair Approach



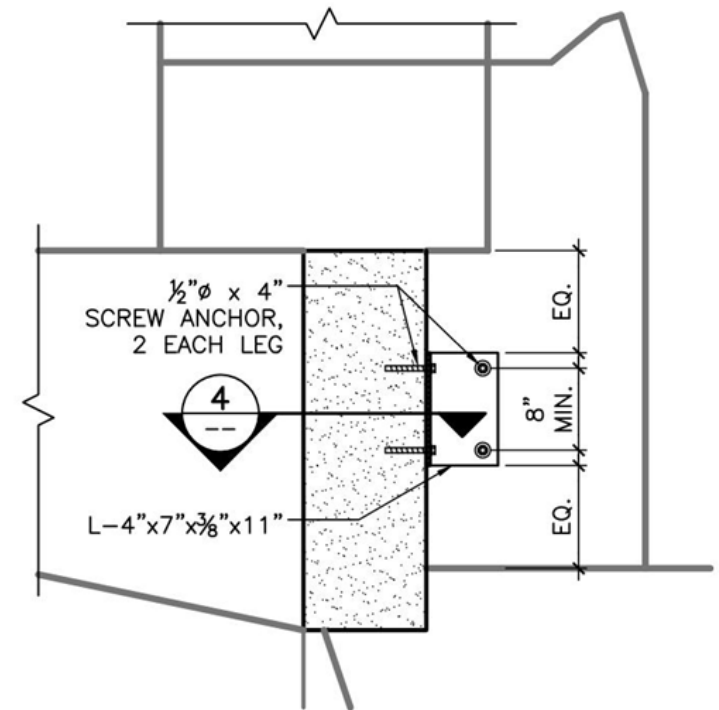
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# Tie Beams at Side Ribs- Anchor Repair

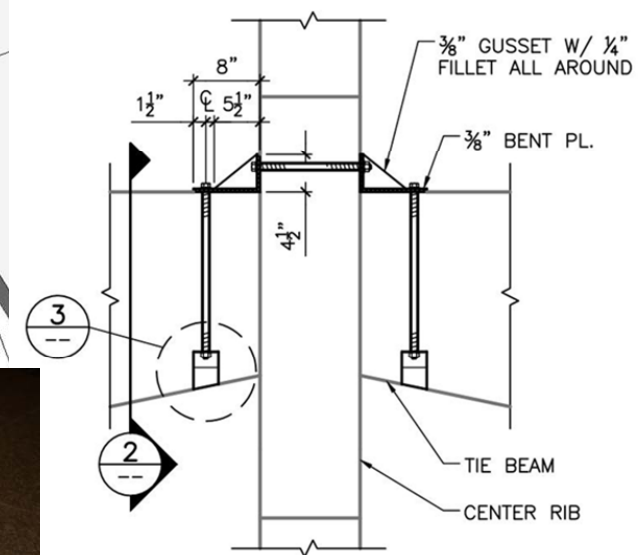
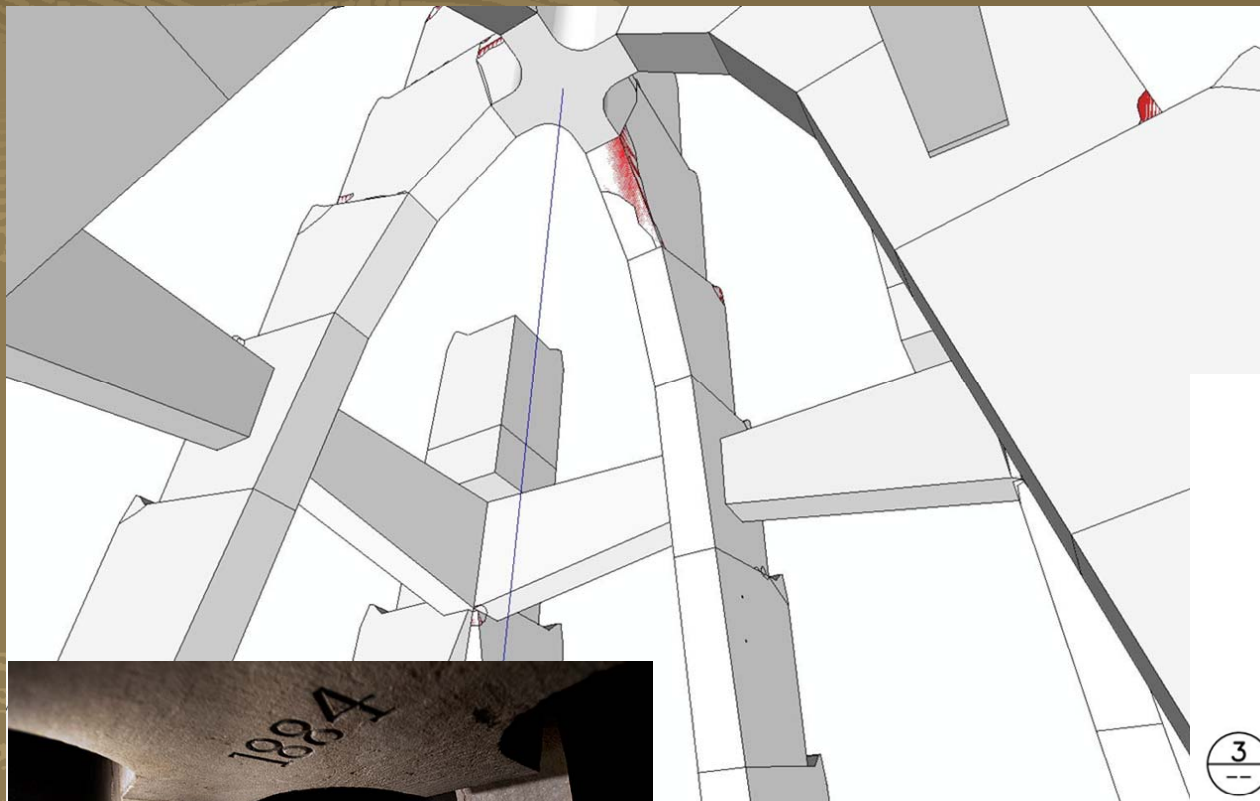


5  
S5.2

SECTION TIBEAM @ END

SCALE (A)

# Cracked Tie Beams at Center Ribs



1  
S5.2

ELEVATION TIEBEAM @ CENTER

SCALE (A)



# Data Work - Ongoing

- Draft Seismic Study to analyze extent of ground motion from August 2011 earthquake completed June 2012; the study analyzed vulnerabilities of the monument to future ground motion. No strengthening methodologies were recommended. NPS review was completed 6/25/12 and Final Report is due July 2012
- Geotechnical borings and analysis
- New full loop survey of geodetic benchmarks on the National Mall by National Geodetic Survey
- Ground motion seismic study by the US Geological Survey

# Current Status of Earthquake Repairs

- Elevator repairs - Completed - June 20, 2012
- Monument Repair Design documents finalized – June 22, 2012
- Solicitation package for repair/construction contract out for bid June 29, 2012
- Anticipated project construction start Fall 2012 w/ construction duration approximately 12 – 18 months