

# Case Study #1

**Poor Geotechnical Engineering + Poor  
Structural Engineering + Poor  
Construction**

**=**

**Poor Foundation Performance**

**+**

**Massive Building Distress**

Location: McKinney, Texas

Size/Use: 60,000 SF – Office Building

Age: Constructed in 2006

Foundation: Slab-on-Grade, Perimeter Grade Beams, Perimeter Piers

Framing: Pre-engineered Steel Rigid Frame

Veneer: Aluminum Siding and Stone

Interior: Gypsum Board and Temporary Partitions

Roof: Standing-Seam Metal Roof

# REPORTED DISTRESS

- ❑ Uneven floors
- ❑ Foundation cracking
- ❑ Exterior veneer distress
- ❑ Interior veneer/finish distress
  - Gypsum board separations
  - Multiple inoperable doors
- ❑ Water intrusion at grade

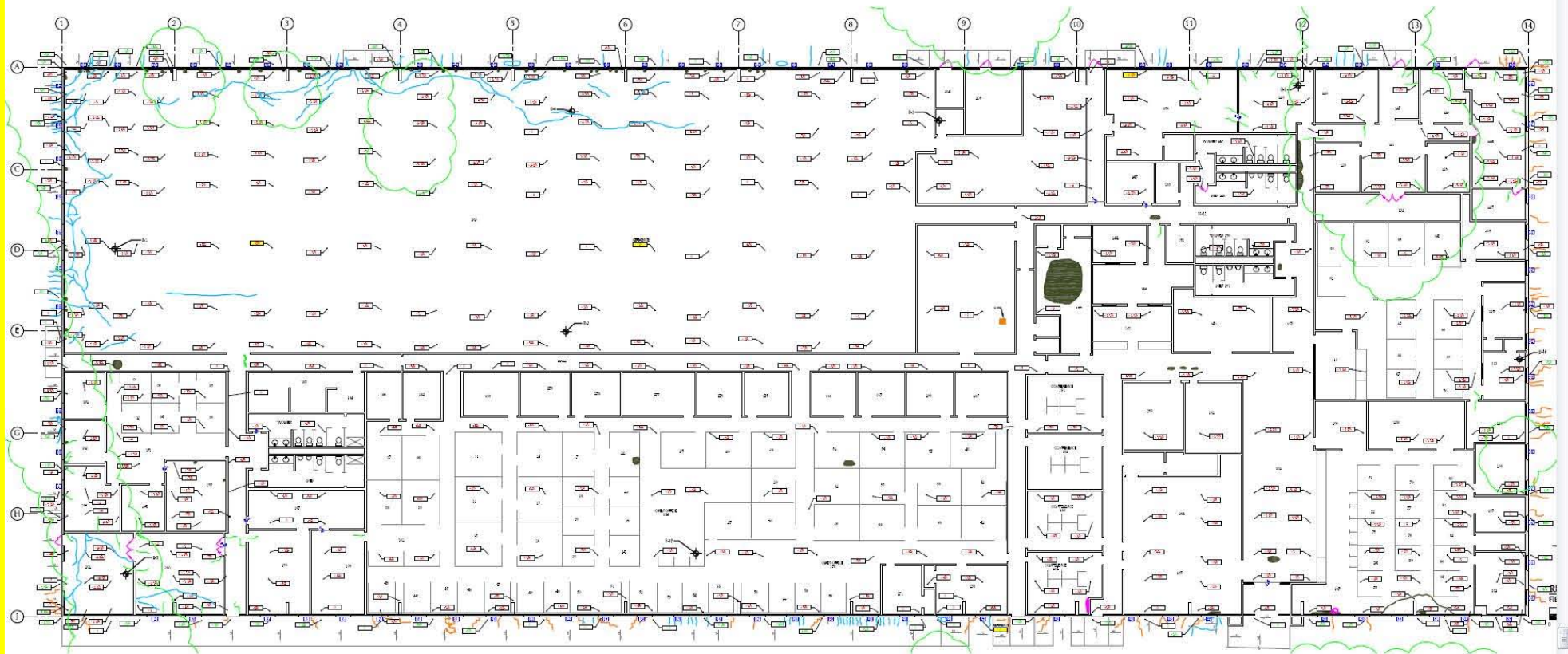
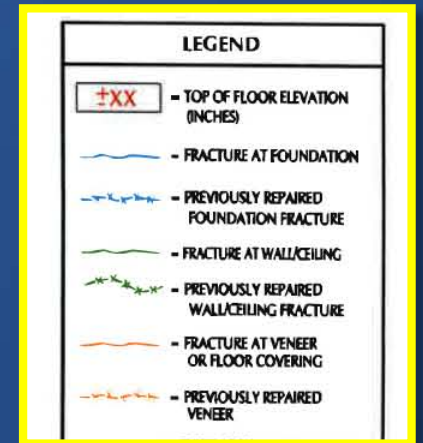
# INVESTIGATION

- ❑ **Documentation of Distress**
- ❑ **Relative Elevation Survey**
- ❑ **Forensic Plumbing Test**
- ❑ **Design Documentation Review**
  - **Geotechnical Engineering**
  - **Structural Engineering**

# Documentation of Distress

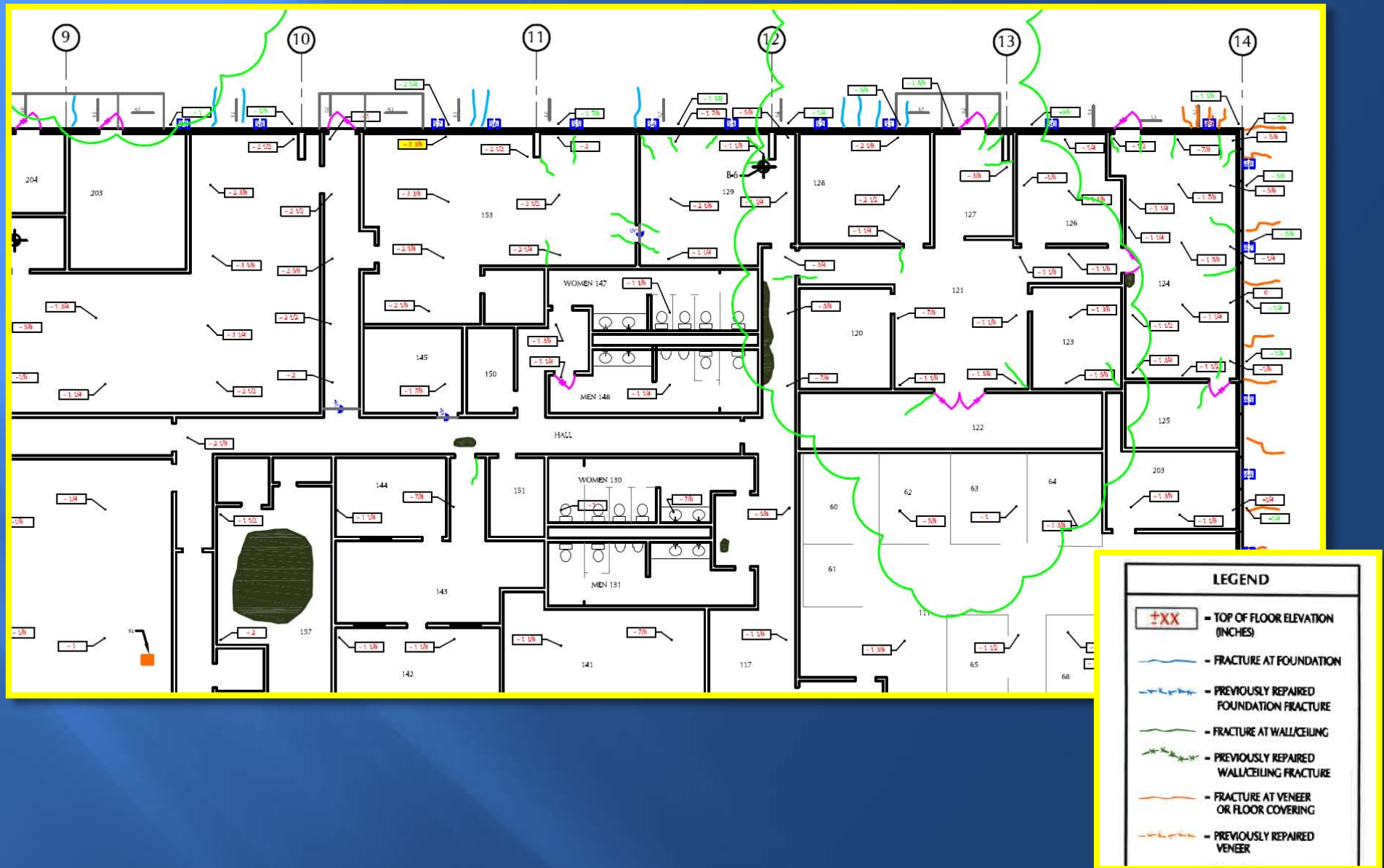
- ❑ **Graphic Documentation**
  - Interior Distress Mapping
  - Exterior Distress Mapping
  - Foundation Fracture Mapping
- ❑ **Photographic Documentation**

# Distress Map





# Distress Map (Close-up)



# Uneven Floors





# Foundation Fractures



# Foundation Fractures



# Exterior Veneer Distress













# Interior Veneer/Finish Distress











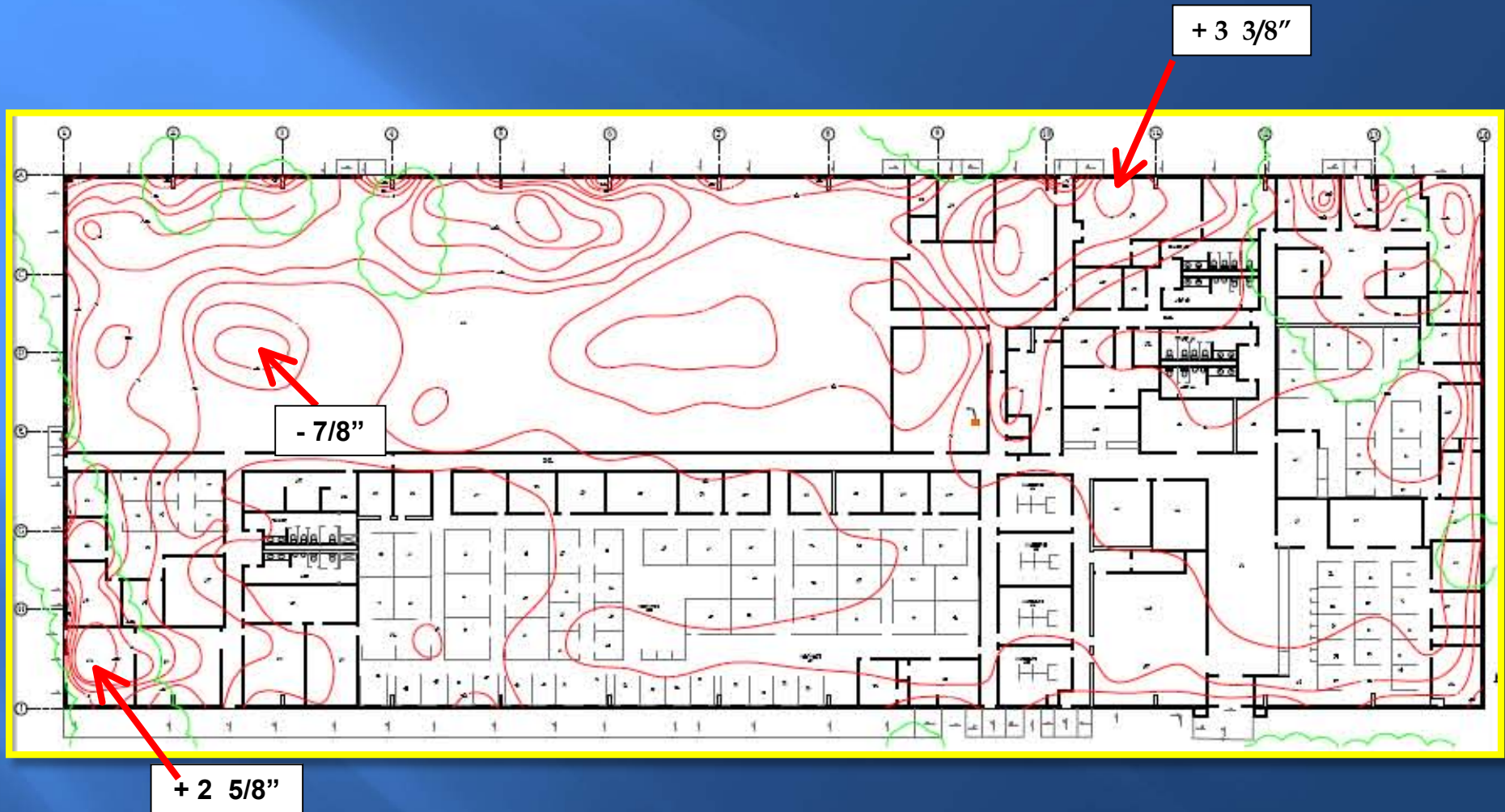
# Inoperable Doors





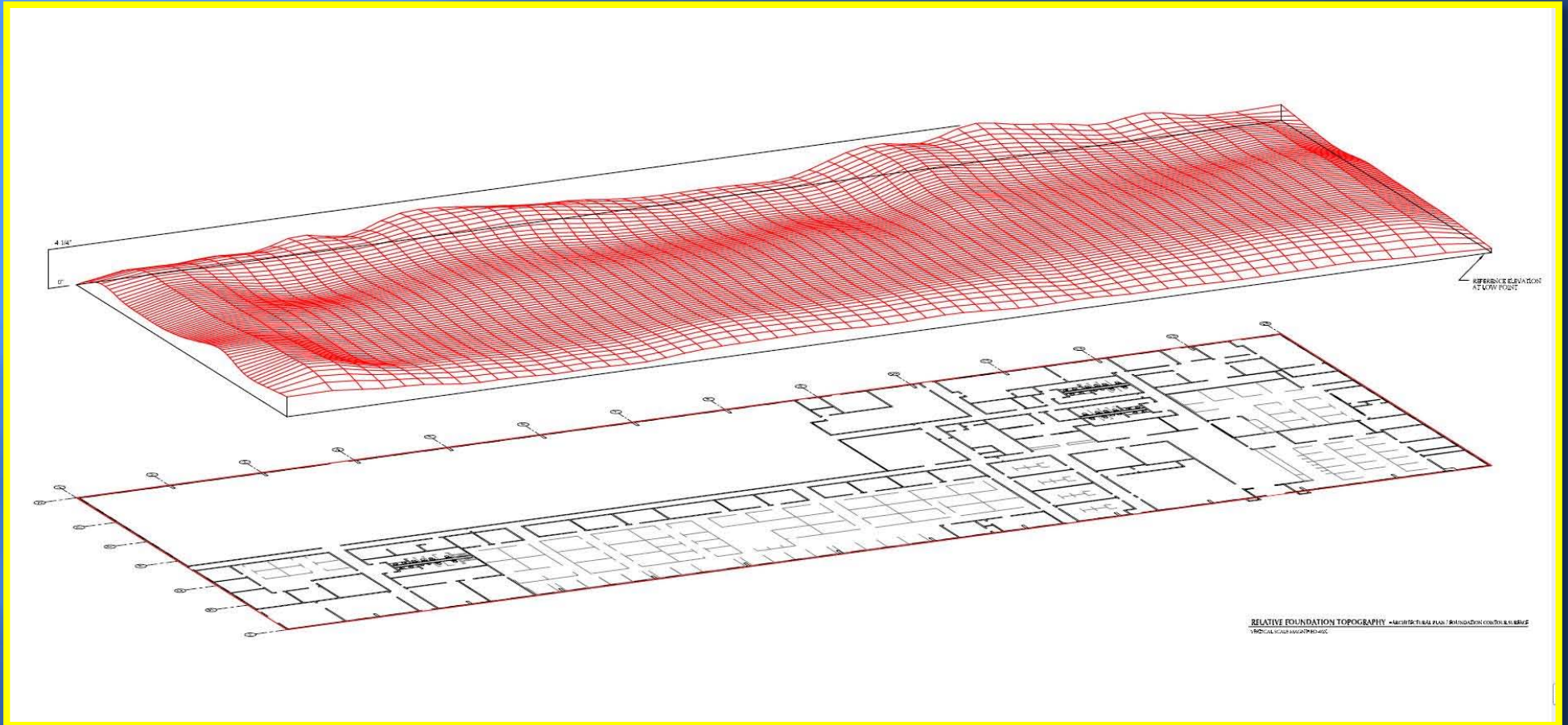


# Relative Elevation Survey (2-D)



Total Out-of-Levelness =  $4 \frac{1}{4}''$

# Relative Elevation Survey (3-D)





# DESIGN REVIEW/ANALYSIS

## Geotechnical Engineering





# Pre-Construction Geotech Report

- 2 borings (20'-25' deep) performed in 60,000+ s.f. building pad:
  - Fat clays at 4' to 8';
  - Calcareous clays below 12';
  - Gray limestone at 15' to 20'
  
- Fat clays:
  - PI = 35% to 47%
  - Swell potential from 0.0% to 1.0%
  - Potential Vertical Rise (PVR) = 2" to 3"

# Preliminary Geotechnical Concerns

- ❑ Insufficient number of pre-construction borings performed
- ❑ No moisture content specification for compaction
- ❑ Miscalculated (underestimated) PVR

# DESIGN REVIEW/ANALYSIS

Structural Engineering



# Pre-Construction Geotech Report

## PIER DESIGN PARAMETERS (FROM PRE-CON GEOTECH REPORT)

- ❑ 40,000 psf end bearing pressure
- ❑ 6,000 psf skin friction for portion embedded into limestone **below 2'**
- ❑ Uplift pressure 2,200 psf to a depth of 12'
- ❑ Uplift force to be resisted by dead load plus skin friction

# Structural Design

## PIER DESIGN PARAMETER

6,000 psf skin friction for portion embedded into limestone  
below 2'

## STRUCTURAL DESIGN REQUIREMENT

All piers to be embedded into limestone ONLY 2'

## AS CONSTRUCTED (FYI)

Piers embedded into limestone to 2.2' maximum (from pier logs)



# Structural Design Analysis

2' diameter pier = 6.3 s.f. surface area/ft depth

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12' active clays @ 2,200psf = **166,300 lb uplift / pier**

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0' embedment into limestone

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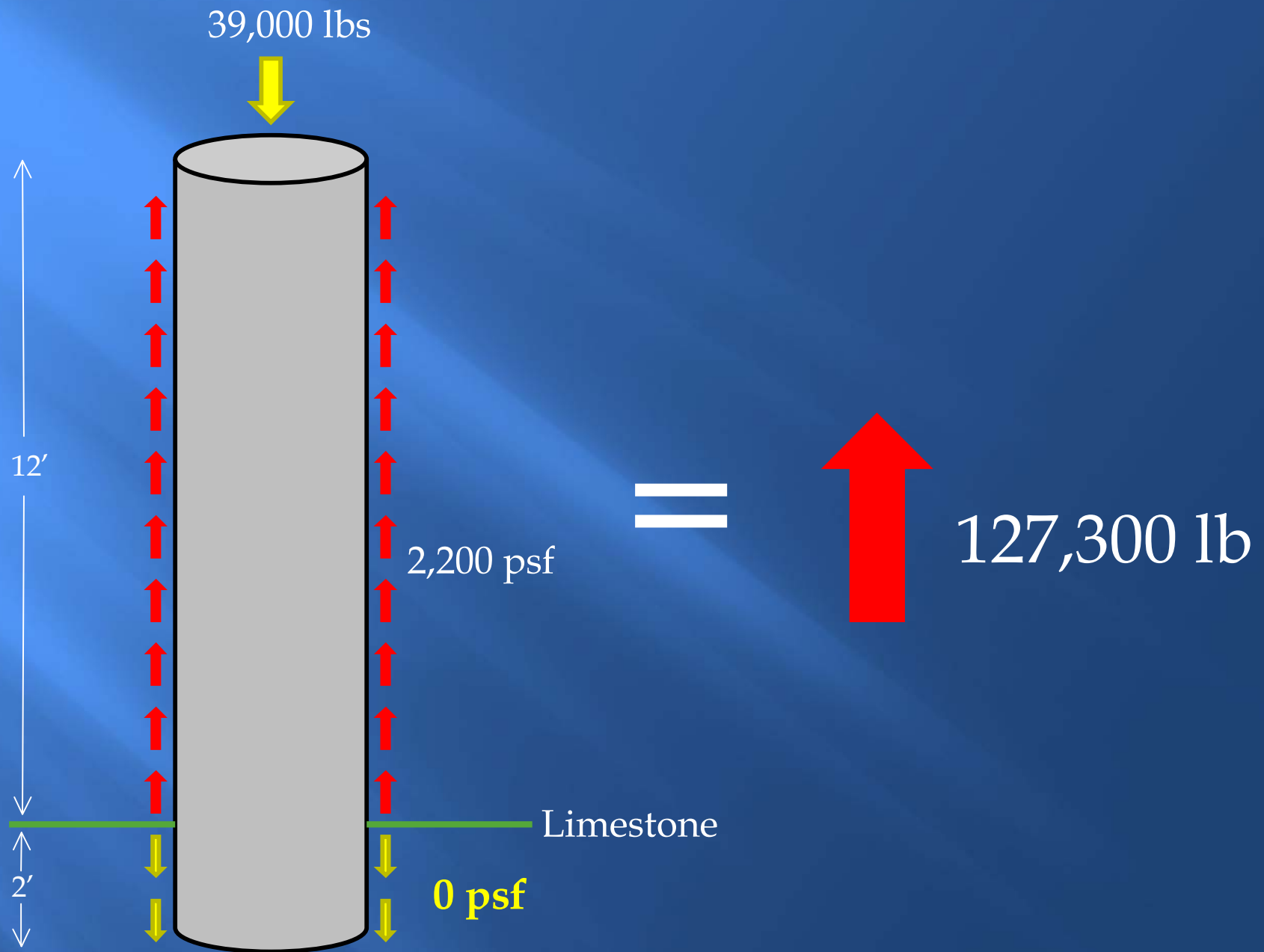
**0 psf allowable** skin friction resistance to uplift

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DL (building + pier + grade beam)  $\approx$  **39,000 lb / pier**

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$166,300 - 39,000 =$  **127,300 lb NET UPLIFT / pier**



# CONSTRUCTION REVIEW/ANALYSIS



# Subgrade

## DESIGN REQUIREMENTS

Undercut pad 4', moisture condition and replace 3', cap with 1' of select fill or lime-stabilized native soil

## AS-BUILT CONDITIONS

- ❑ No select fill used; lime stabilization inconsistent
- ❑ Moisture conditioning poorly performed



# Foundation

1' turn-down slab utilized instead of 36" grade beam at one elevation

# Grading & Drainage

- ❑ Grade sloped **toward** building
- ❑ Ineffective rain guttering system along the perimeter



# CONCLUSIONS

Foundation Movement caused by:

- ❑ Inadequate pre-construction geotechnical investigation
- ❑ Incorrect geotechnical calculations
- ❑ Improper structural design based on the (inadequate) geotechnical report
  - ❑ Piers not embedded deep enough into rock to resist uplift
  - ❑ Grade beam not sufficiently deep to resist uplift
- ❑ Failure to place select fill
- ❑ Failure to moisture condition soils
- ❑ Neutral and negative grading around perimeter of structure
- ❑ Inadequate guttering system

# RECOMMENDATIONS

- ❑ Additional soil testing of the subgrade
- ❑ Move tenants out of building, remove interior finishes and partitions
- ❑ Excavate and demolish slab and grade beams
- ❑ Undercut and moisture condition the subgrade
- ❑ Place 1' layer of compacted select fill
- ❑ Remedial piers installed at all existing deficient piers
- ❑ Perimeter grade beams and slab formed, reinforced, and re-poured



# COST

Original Construction:  $\approx$  \$5 Million

Remediation:  $\approx$  \$5 Million