

# DYNAMIC CABLE BRACING FOR MULTI-HAZARD MITIGATION

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# Overview

- The problem: Progressive Collapse
- The solution: Dynamic Cable Bracing
- Comprehensive analysis method:  
from bomb to collapse

# Problem Statement

There are many existing municipal buildings not designed for earthquake loading

These buildings have little progressive collapse resistance

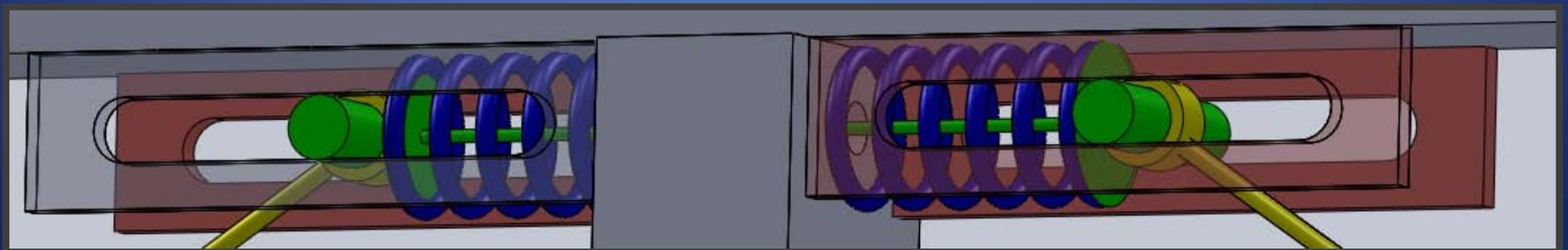
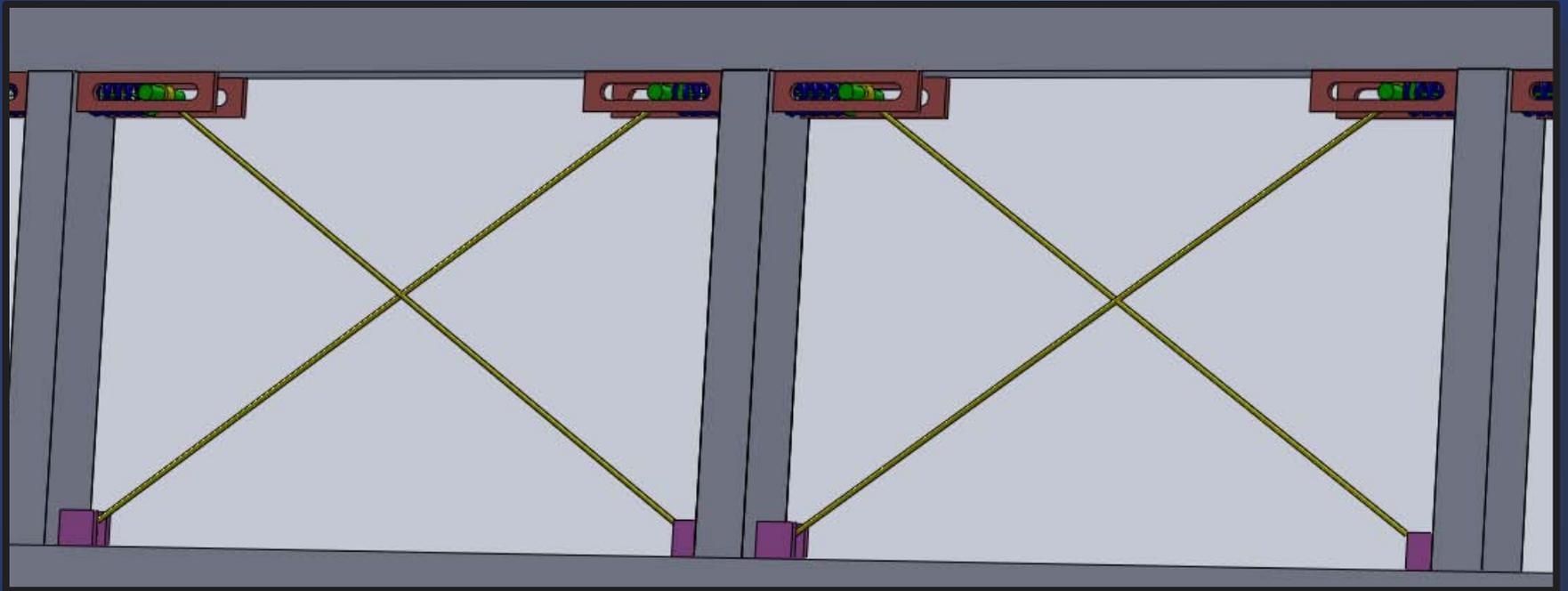
Example: Oklahoma City Bombing, the Murrah Federal Building

Progressive Collapse causes  
~ 90% of damage

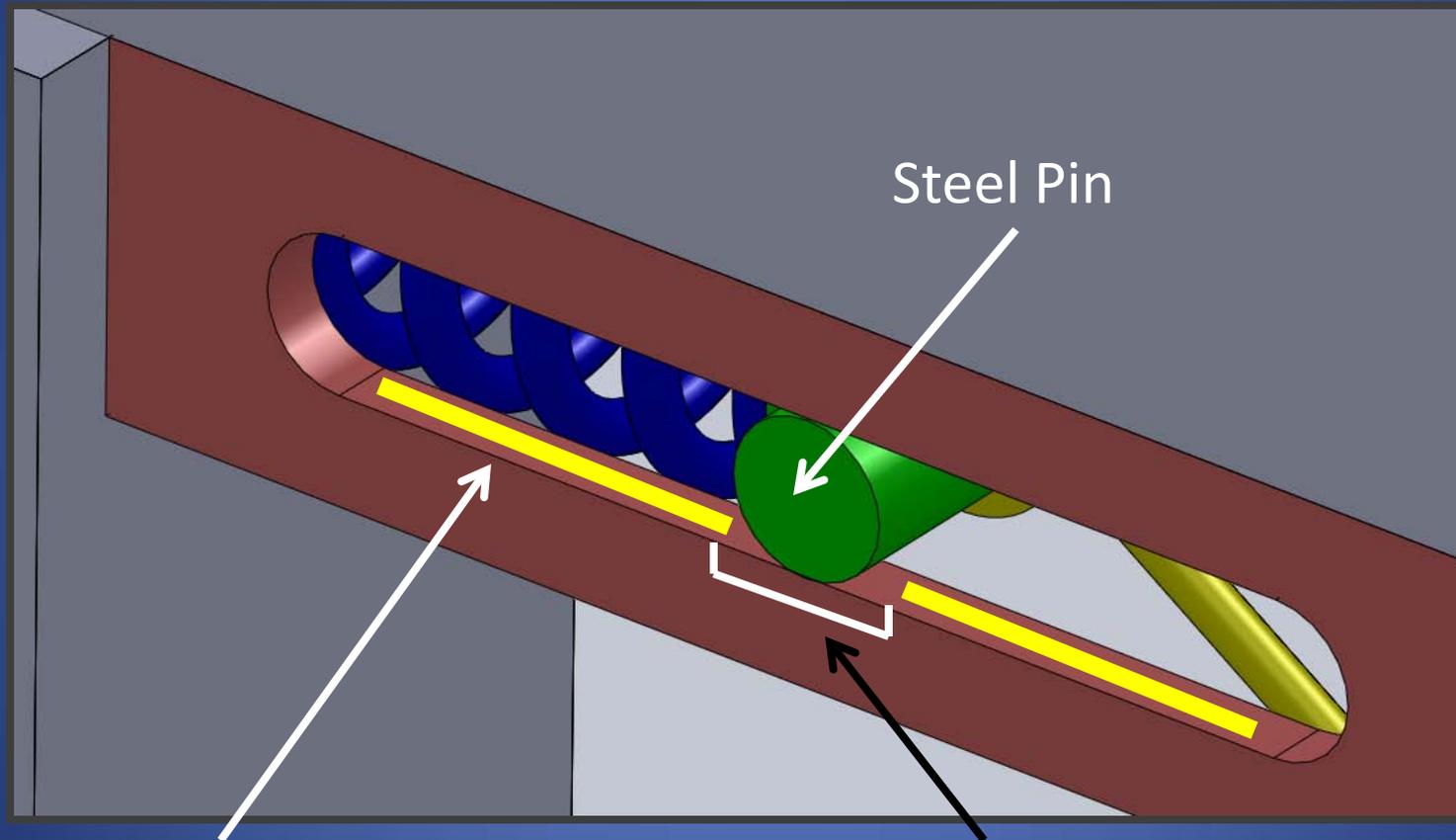


# The Solution: Dynamic Cable Bracing

Provides Energy Dissipation, Redundancy, and Ductility



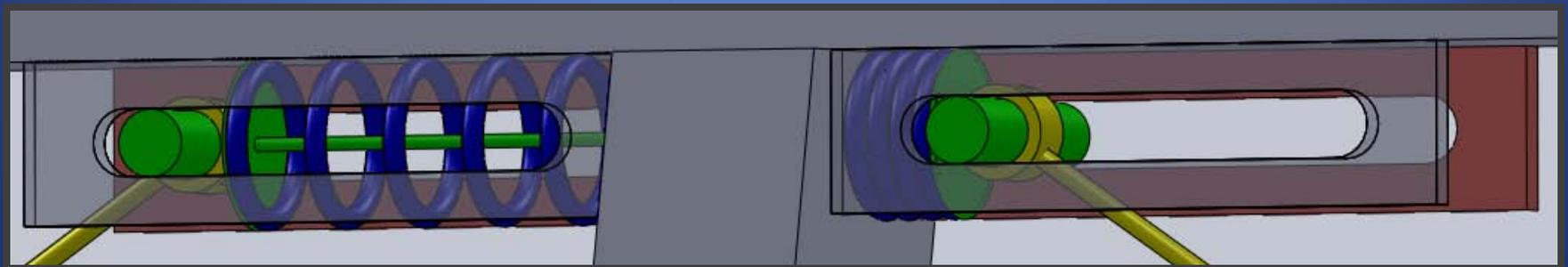
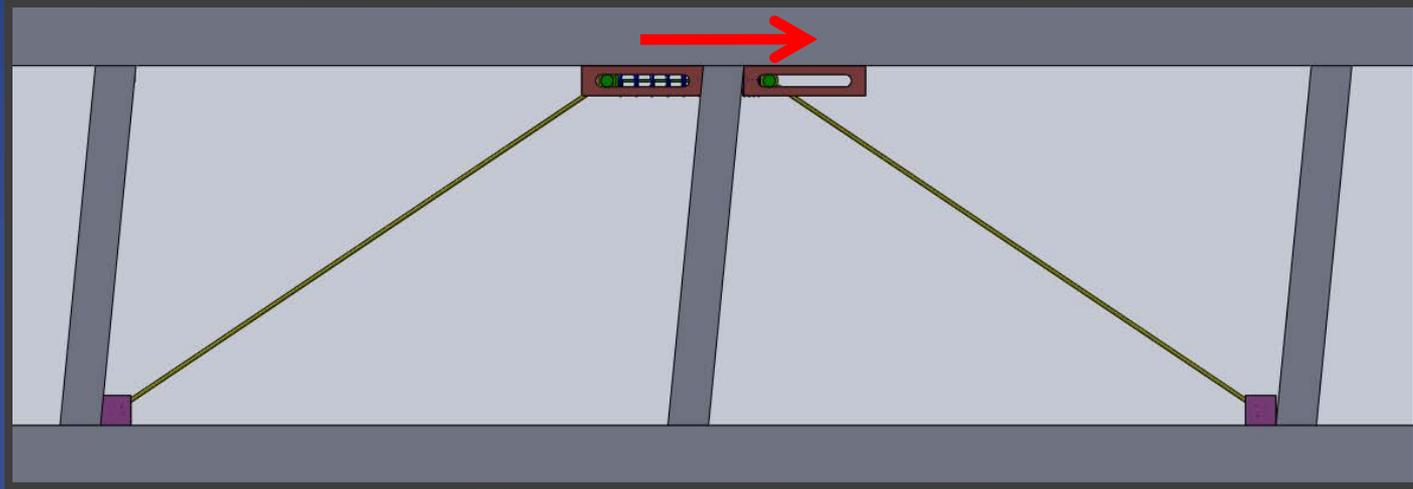
# The System: Friction Damping



High friction surfaces dissipate large displacement energies (i.e. steel on steel)

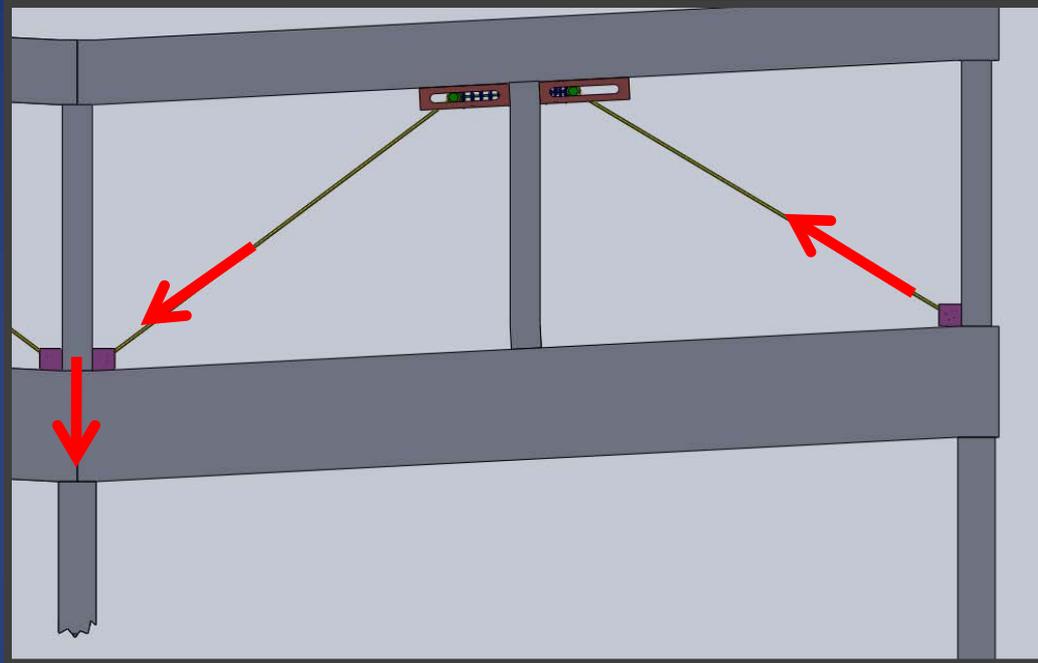
Directly under pin: Low friction (i.e. polyethylene) Allows small vibrations

# The System: Seismic Deformation

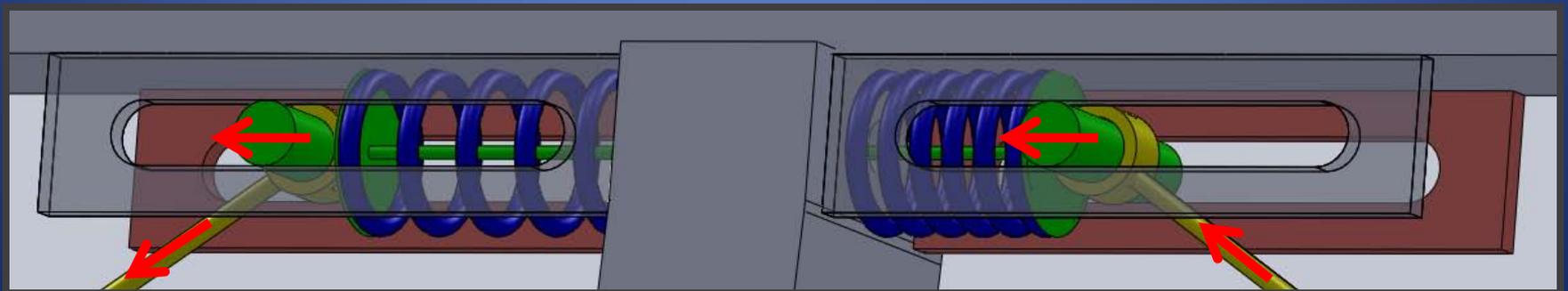


Cables always taught, Friction damping absorbs seismic energy, springs provide self-centering

# The System: Blast Deformation



System distributes load away from damaged area



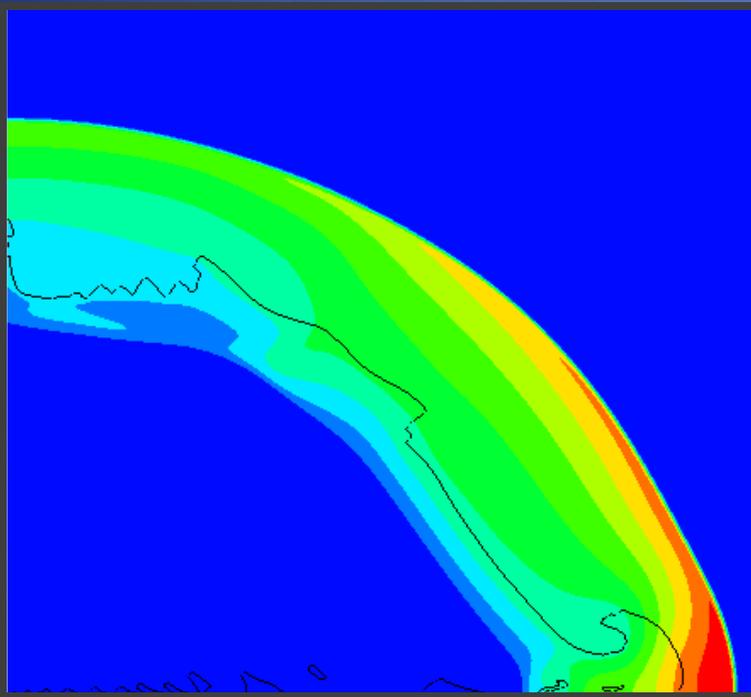
# Analysis: From Bomb to Collapse

- Develop analysis method to predict all aspects of blast-induced progressive collapse
- Goal: correctly predict collapse extent seen in Murrah Building
- Use validated analysis method to analyze and prove Dynamic Cable Bracing System

# Analysis: From Bomb to Collapse

- Important mechanics in blast to collapse:
  - Blast pressure amplification from:
    - Shock interactions with ground, Mach stem forming
    - Oblique shock reflections off column faces
  - Dynamic column failure under impulse loading
  - Collapse of structure under gravity load once damaged columns are removed

# Analysis: Hydrocode Modeling



2D Analysis:  
Shock interaction with ground  
Mach stem formation

3D Analysis:  
Air blast flows around column  
Oblique shock reflections on face  
Pressure spike on column front

