A Case Study of Historical Building Seismic Upgrade

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Introduction

- 6 Story Concrete Structure with Full Basement
- 145,000 ft² (13,470 m²)
- Built in 1910
- Located in Stockton, California
- A National Historic Registered Structure
- Mix Usage:
  - Residential
  - Retail
  - Parking Garage
Elevation
Performance Based Design

• Identify Seismic Demand
• Identify Deficiencies by Simplified Methods
  1. Linear Dynamic
  2. Nonlinear Static
• Identify Performance Goal
  1. Collapse Prevention at DBE
• Identify Retrofit Measures to Control Deficiencies
  1. Linear Dynamic
• Provide Nonlinear Dynamic Analysis to Verify Results of Simplified Methods
First Mode: $T=1.3$ Sec.
2\textsuperscript{nd} Mode: T=1.2 Sec.
Progressive Hinge Formation
Performance Goal

- Collapse Prevention @ DBE
- Reduce Soft-Weak Story Effect Without Increasing Demand on Upper Floors
- Reduce Torsional Effect Without Increasing Demand on Upper Floors
Retrofit Methods

- FRP: Increase Ductility at Ground Floor Columns
- Plywood Shearwalls: Control Diaphragm Response Above 2nd Floor
2nd Floor Upgraded Structural Plan

\[ \begin{align*}
A &= FVD \\
B &= FVED
\end{align*} \]

10 Dampers Each Direction
Damper Frame Elevation
Fluid Visco-Elastic Damper

- Fluid Viscous Damper + Poly Urethane Elastomer
- Aerospace and Military Applications (Classified)
- Consistent Properties: 0°F to 225°F (-18°C to 107°C) No Molecular Damage and Elasticity
- Aging Under Static Stress: Consistent Properties
- Fire Resistance: Federal Aerospace Regulations 25.853B

Miyamoto International
Fluid Visco-Elastic Damper Response
2nd Mode: $T = 1.0 \text{ sec}$
Time History Analysis

$\Delta_{\text{max}} = 0.56 \text{ in. (14 mm)}$

$\Delta_{\text{max}} = 3.5 \text{ in. (89 mm)}$

$\Delta_{\text{yield}} = 0.85 \text{ in. (22 mm)}$

*Miyamoto International*
Time History Analysis

\[ \Delta_{\text{max}} = 0.85 \text{ in. (22 mm)} \]

\[ \Delta_{\text{max}} = 4.8 \text{ in. (122 mm)} \]

\[ \Delta_{\text{yield}} = 1.44 \text{ in. (37 mm)} \]
Conclusions

- Drift Ratio: 0.004 @ Ground Floor
- Spectra Acceleration: 0.12g.
- Elastic Response
- Structural Cost: $1.3 Million ($9/ft² or $96/m²)
- Total Cost: $24.0 Million ($165/ft² or $1,980/m²)