ASSESSMENT OF SELF-CENTERING POST-TENSIONED CONCRETE BRIDGE PIERS

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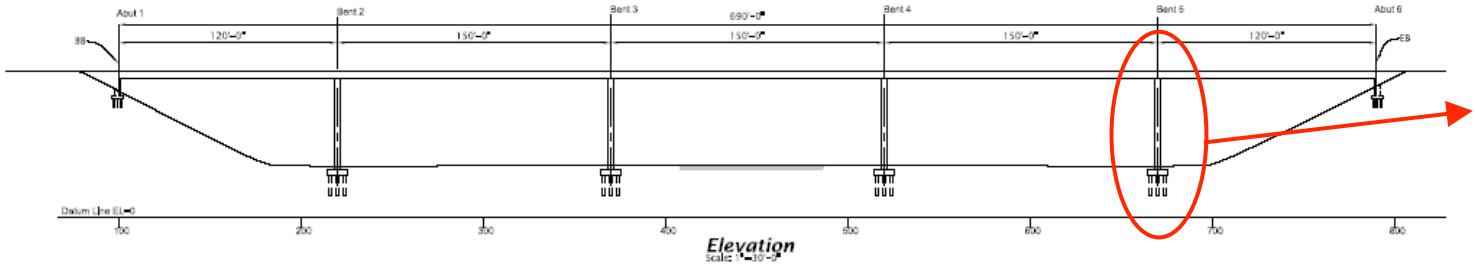
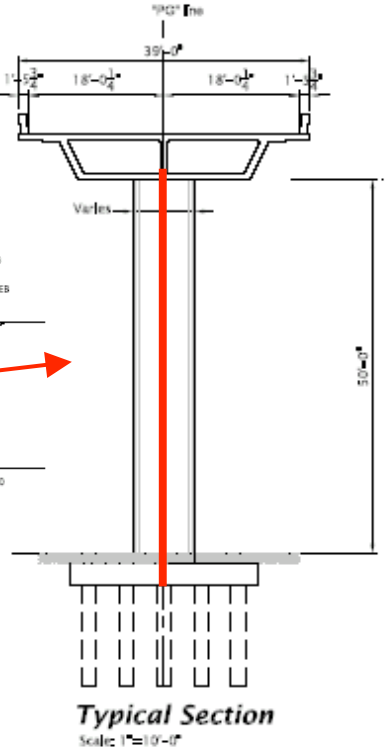
PBEE Assessment of RC & UBPT Bridges

Benchmark Bridge

55’ columns and 22’ columns





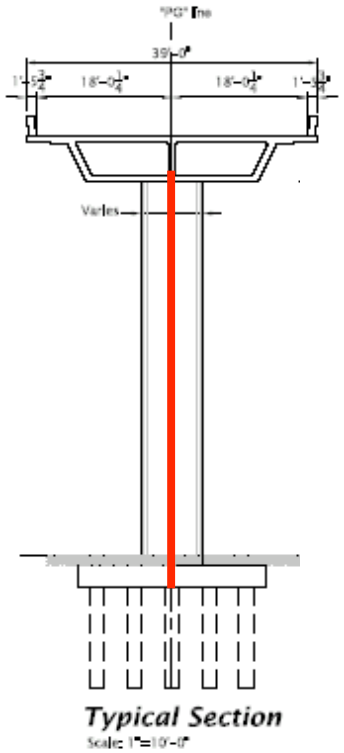
- Designed by Caltrans engineers
- Representative bridge structure
- Design UBPT based on Sakai et al. 2005
- Set of 17 near-fault ground motions

Replace RC Column with Self-Centering Column

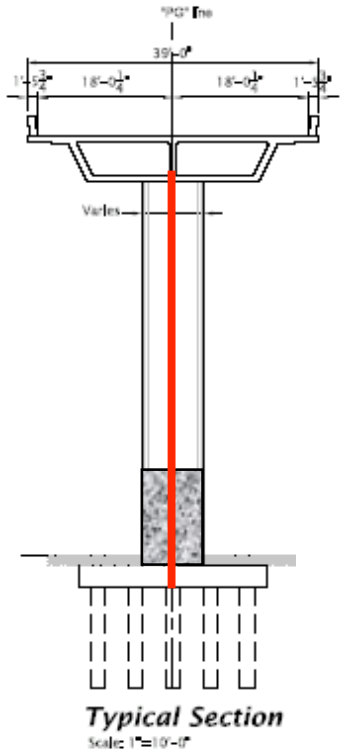
PBEE Assessment of RC & UBPT Bridges

UBPT Systems Evaluated

UBPT

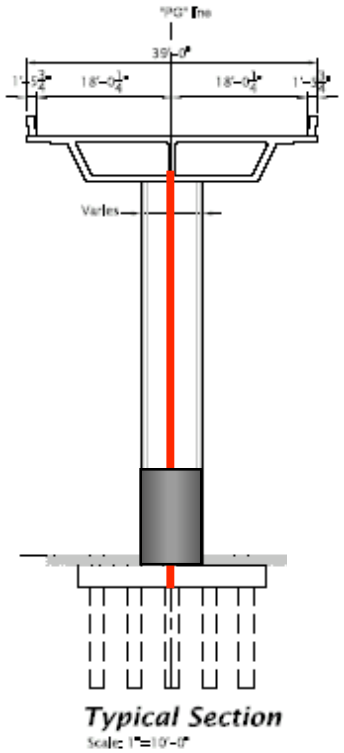


ECC



- Fine, multiple cracking
- No spalling
- Delayed bar buckling

Steel Jacket



- No spalling
- No bar buckling

Accomplishments

Assessment of Self-Centering Bridges

1. Simulation methods for predicting behavior of RC and UBPT systems
   - *Modified constitutive model implemented - able to predict residual displacements with fiber models*
   - *Preliminary evaluation of correlation btwn peak and residual drift (benchmark results vs. Kawashima model). Need more experimental data to validate – possibly develop new model.*
2. Structural and performance assessment of UBPT systems (50’ and 22’ bridge columns)
   - *Enhanced-performance UBPT systems have reduced residual displacements and damage relative to baseline reinforced concrete systems*

Accomplishments

Assessment of Self-Centering Bridges

3. Systematic comparison with conventional RC systems

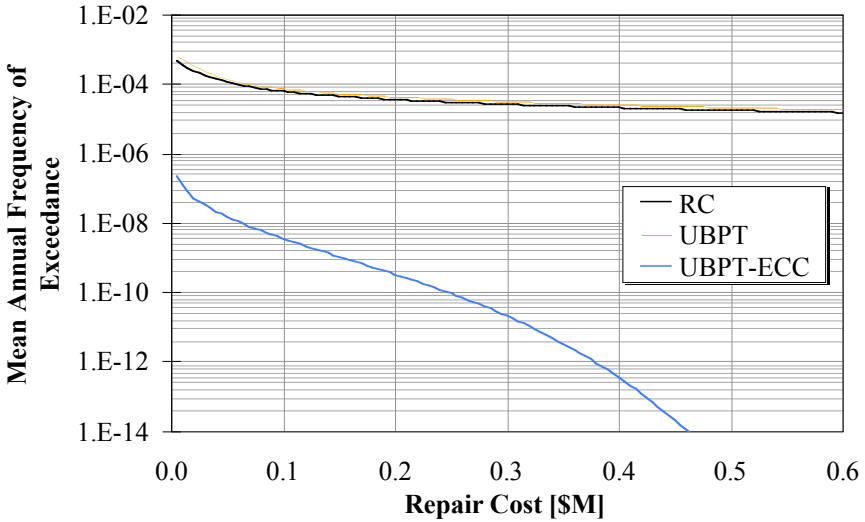
   - *RC & UBPT bridges have similar peak drifts*
   - *UBPT bridge has significantly lower residual displacements than RC bridge → Reduced downtime, reduced repair costs*
   - *Greatest reductions in cost and downtime seen with use of damage-tolerant concrete (ECC) and steel jackets*

PBEE Assessment of RC & UBPT Bridges

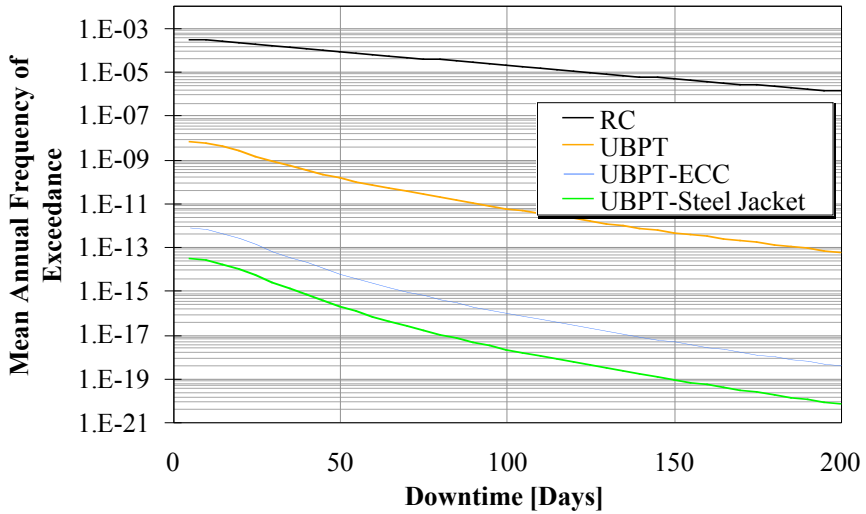
Hazard Analysis → Structural Analysis → Damage Analysis → Loss Analysis

$$\nu(DV) = \iiint G\langle DV \mid DM \rangle \mid dG\langle DM \mid EDP \rangle \mid dG\langle EDP \mid IM \rangle \mid d\lambda(IM)$$

Repair Cost Hazard Curve



Downtime Hazard Curve

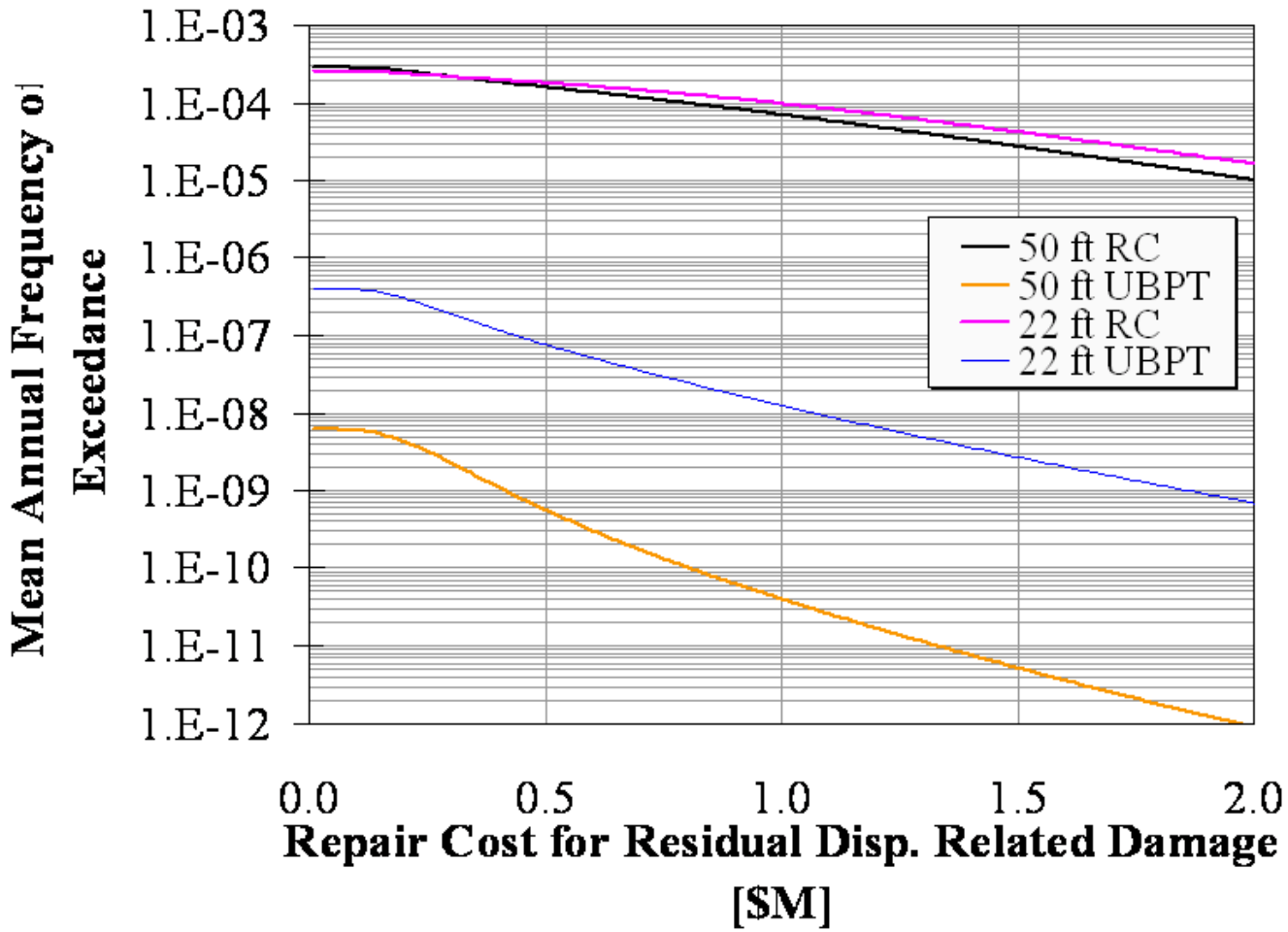


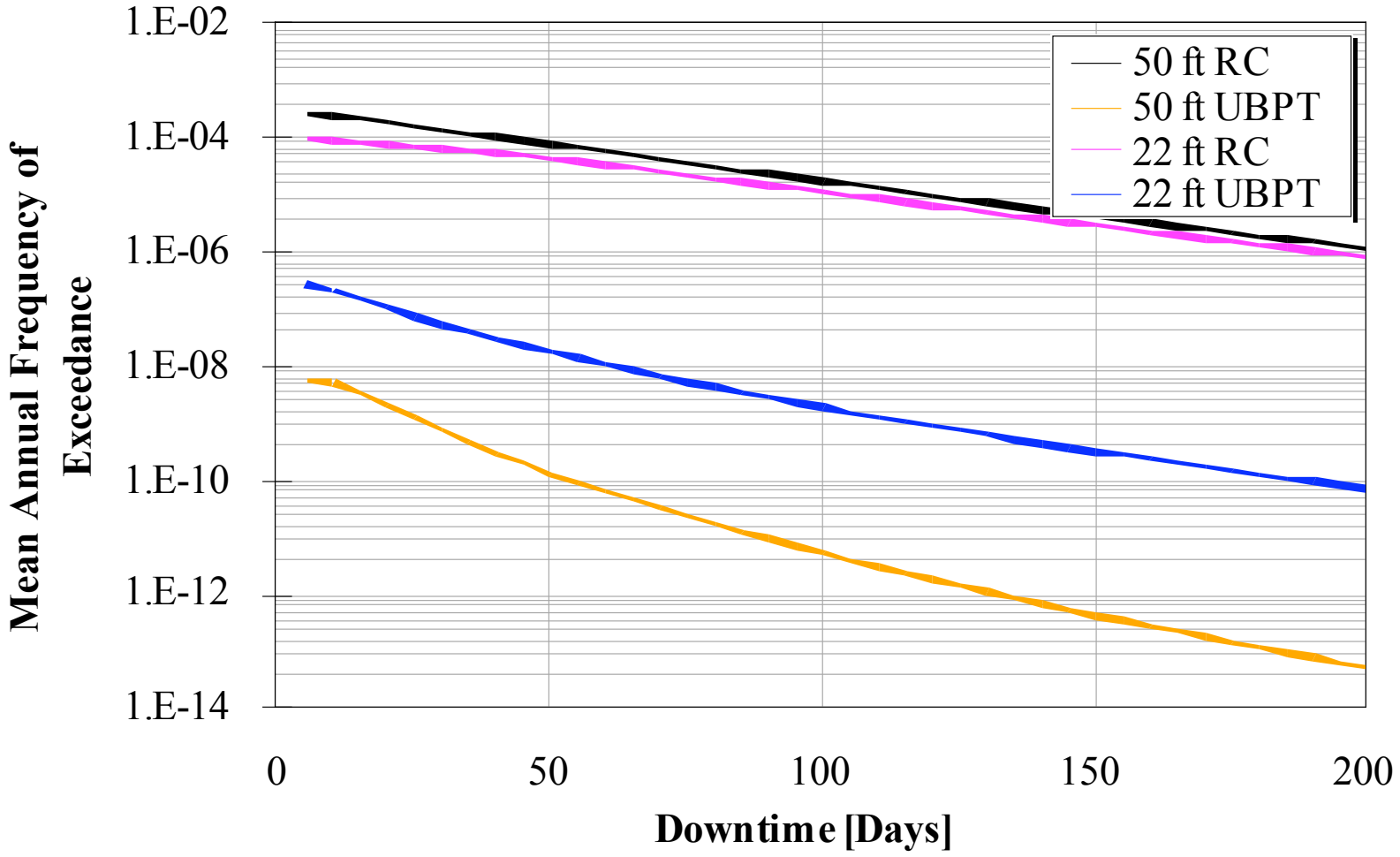
- Enhancements provide improved performance
- This particular RC bridge performed well with or without enhancements

PBEE Assessment of RC & UBPT Bridges

Hazard Analysis → Structural Analysis → Damage Analysis → Loss Analysis

Repair Cost Hazard Curve: 50' vs. 22' columns




Mean Annual Frequency of Exceedance
1.E-02
1.E-04
1.E-06
1.E-08
1.E-10
1.E-12
1.E-14
0
50
100
150
200
Downtime [Days]
50 ft RC
50 ft UBPT
22 ft RC
22 ft UBPT

Accomplishments

Assessment of Self-Centering Bridges

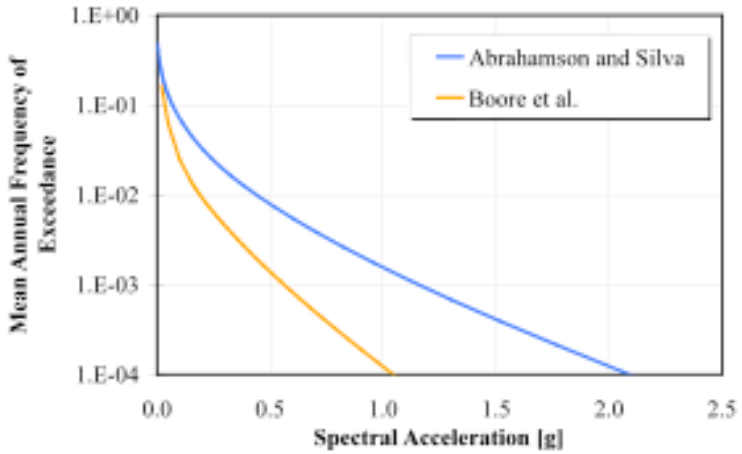
4. Evaluation of PEER PBEE Assessment methodology

   - *Demonstrated to be a useful and powerful tool for systematic comparison of alternative structural systems for a design*
   - *Results are most sensitive to the assumptions made in the hazard analysis*

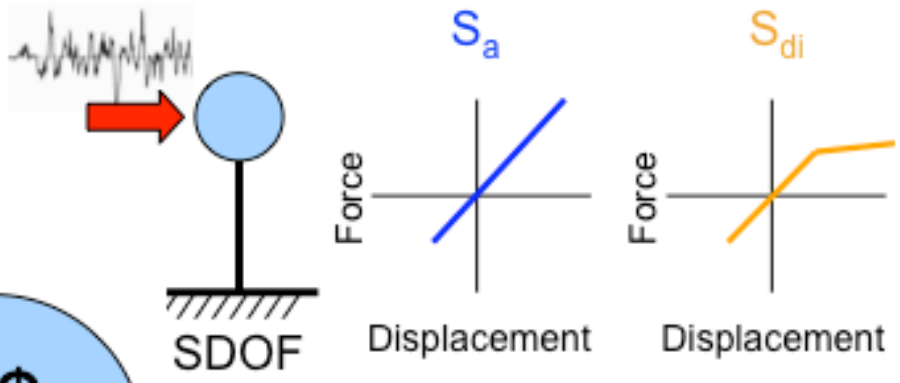
PBEE Assessment of RC & UBPT Bridges

Sensitivity Study – impact of assumptions made

Hazard Analysis

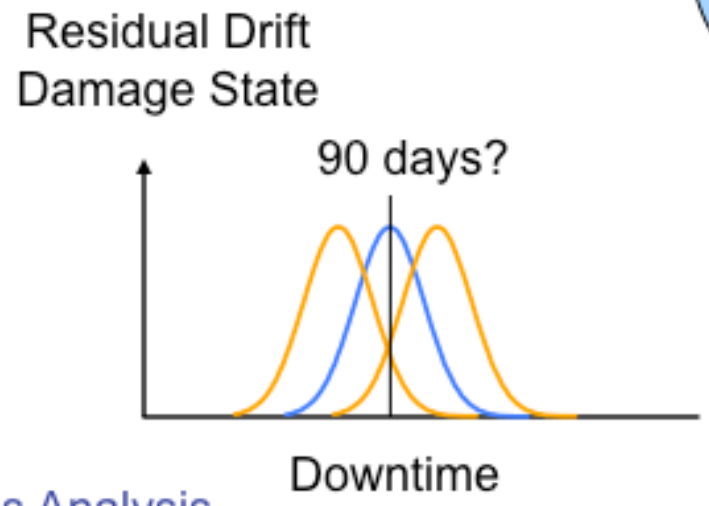


Structural Analysis

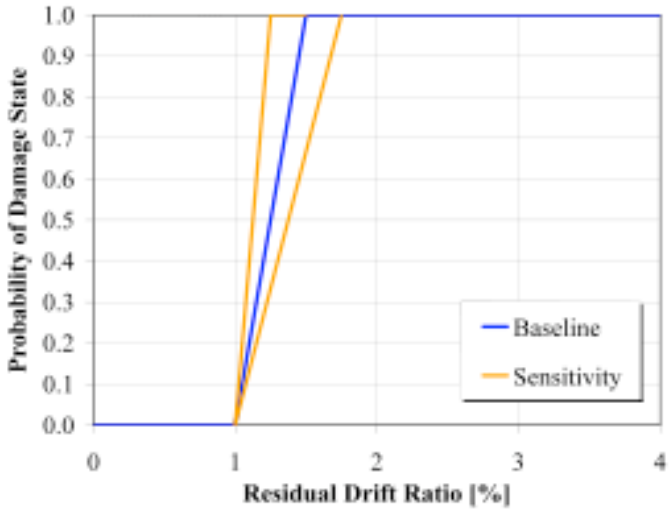


$$ Downtime

Loss Analysis



Damage Analysis



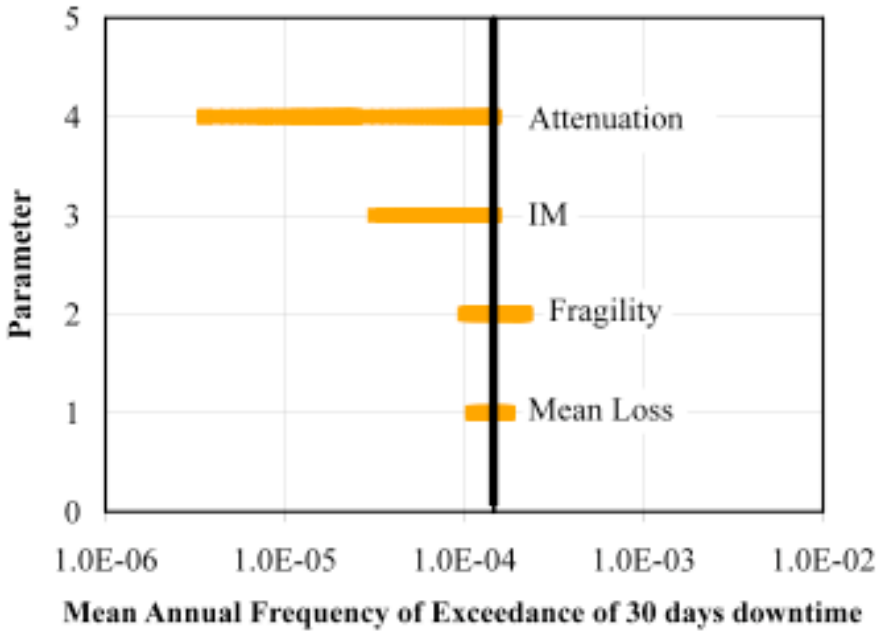
PBEE Assessment of RC & UBPT Bridges

Sensitivity Study – impact of assumptions made

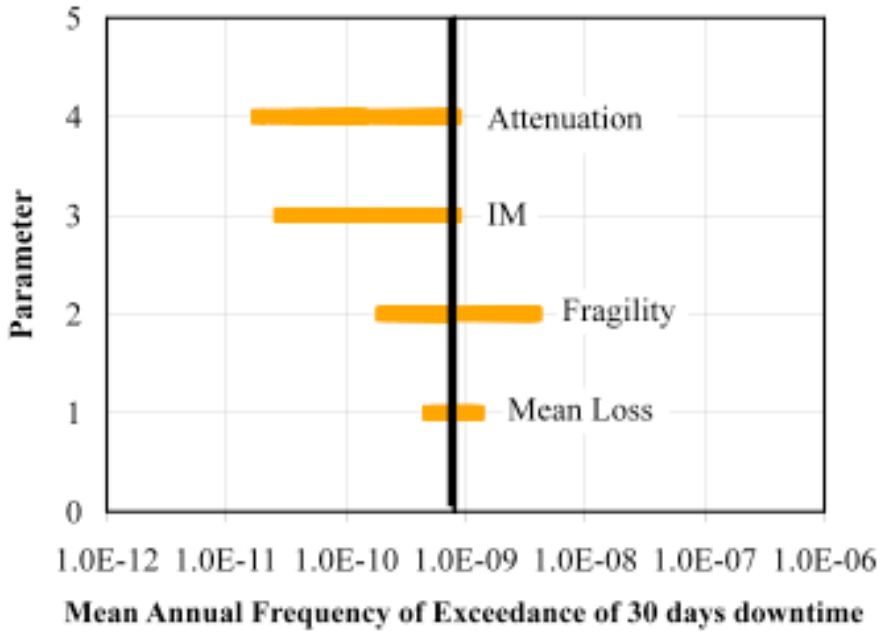
Perform assessment again considering alternatives.

Look at downtime of 30 days.

Which factors affect the final result the most?



RC Columns



UBPT Columns

Note: Different Scale

Contributions

Performance-based Assessment of Self-centering Structural Concrete Bridge Piers

- Prediction and analysis methods for UBPT bridge piers
- Example of applying PEER PBEE methodology to evaluate multiple designs of an alternative structural system
- Demonstration of the impact of assumptions made at various steps of the PBEE methodology

Ideas for Future Work

Experimental validation of alternate pier designs

- Use of High Performance FRC materials in hinging regions
- Evaluation of precast UBPT piers (extend previous work)
- Develop model for correlation of peak and residual drifts

Performance-based assessment of bridge components made with traditional vs. low-environmental impact cements

- Normal setting, high fly-ash cements
- CO_2-sequestering supplementary cementitious materials

Performance-based assessment of bridge components considering aging of infrastructure

- Evaluation of seismic vulnerability of bridges with deteriorated vs. new reinforced concrete

Thank you

(I’m sorry I couldn’t join in person. This is where I probably am right now.)

Website

http://www.peer.berkeley.edu