Reducing Earthquake Impact on Critical Infrastructure Lifelines

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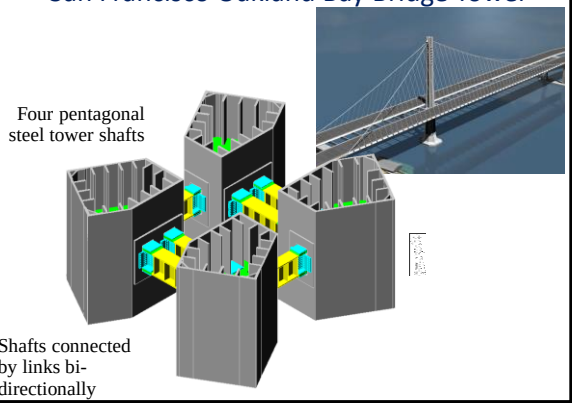
Outline

- Increasing infrastructure system resiliency
  - Identify potential earthquake risk and vulnerabilities
  - Effective EQ mitigation measures to minimize earthquake impact
- Tools to improve seismic performance of infrastructure lifelines
  - Basic research in earthquake resistant design and construction
  - Development of technologies and measures for system-wide mitigation in new and existing infrastructure lifelines

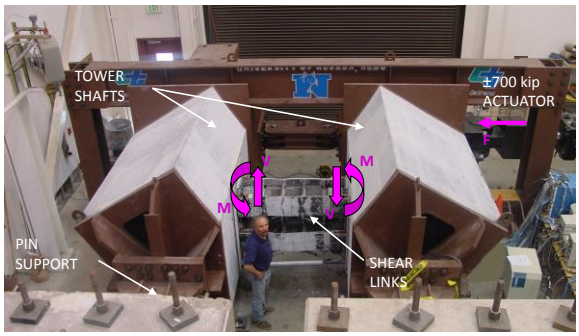
Examples of Improving Seismic Resiliency of Bridges

- Role of experimental testing in improving the seismic performance of bridges
  - Use of High Performance Steel (HPS) and Low Yield Point (LYP) steel to improve seismic response in energy dissipation
  - Understanding the behavior of curved bridges

San Francisco Oakland Bay Bridge Tower



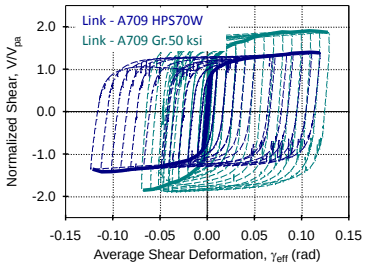
Subassembly Experiment



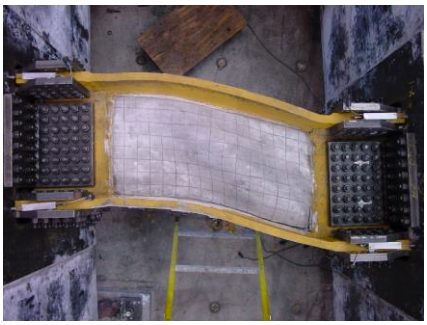
Failure Mode of Links with Conventional Steel (A709 Gr 50)

Failure Mode of Link with High Performance Steel (A709 HPS Gr 70W)

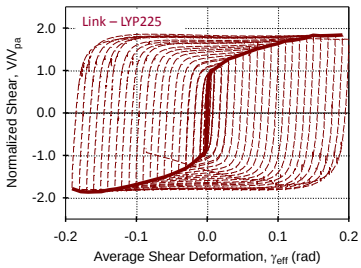
Cyclic Response of Links with HPS and Conventional Steel



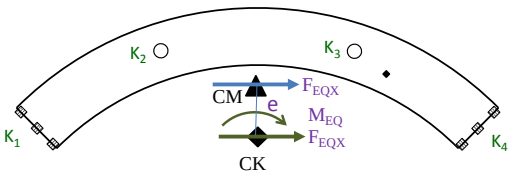
Failure Mode of Links with Low Yield Point Steel (LYP 225)



Cyclic Response of Link with LYP Steel



Seismic Response of Curved Bridges Lateral Load in X-Direction

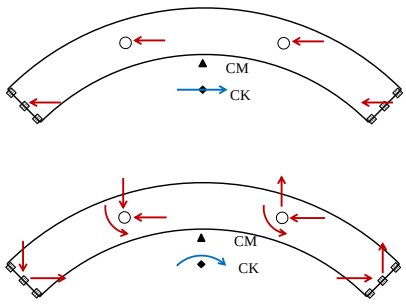


▲ Center of Mass-CM

◆ Center of Stiffness-CK

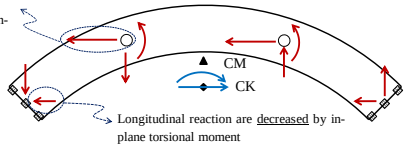
$M_{EQ} = F_{EQX}\ e$

Support Reactions due to Lateral Loading



Support Reaction due to Lateral Loading

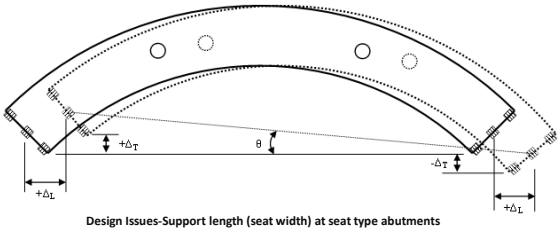
Longitudinal reaction are **increased** by in-plane torsional moment



Design Issues- R/C Columns are subjected combined effect of axial, flexure, and torsion

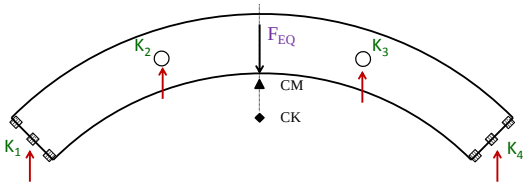
Response due to Lateral Loading X-Direction

Longitudinal AND transverse displacements due to in-plane torsional rotation.



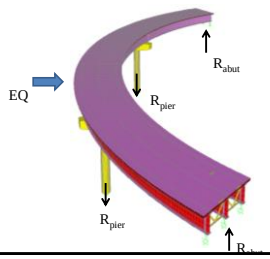
Design Issues-Support length (seat width) at seat type abutments

Lateral Loading Y-Direction



Effect of Lateral Loading in the Y-Direction

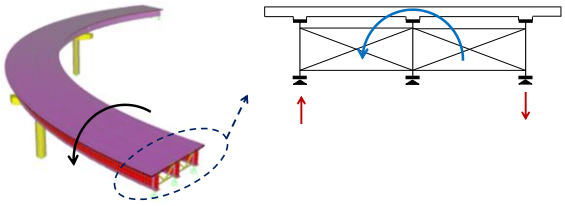
- Framing Action on the bridge
  - Vertical reactions at the abutments and piers
  - Fluctuation of axial loads in columns.



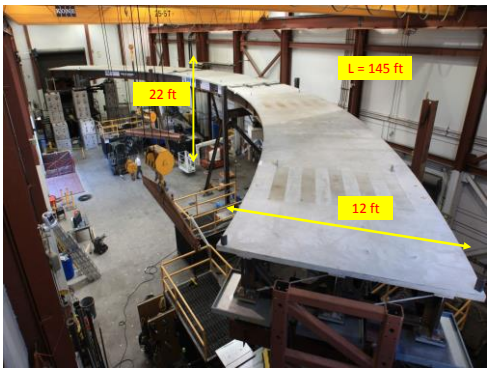
Note: Lateral and moment reactions are not shown for clarity.

Effect of Lateral Loading in the Y-Direction

- Torsional Response of the superstructure
  - Vertical reactions at bent caps and abutments
  - Uplift at abutments if unrestraint

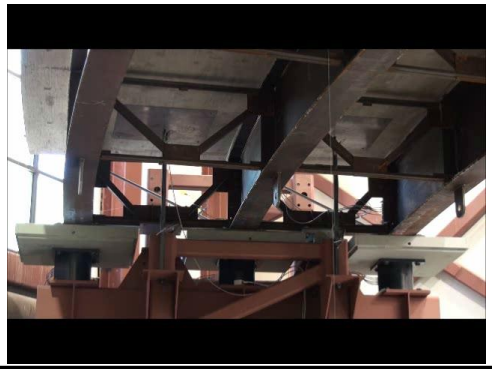


Curve Bridge on the UNR EQ Simulator

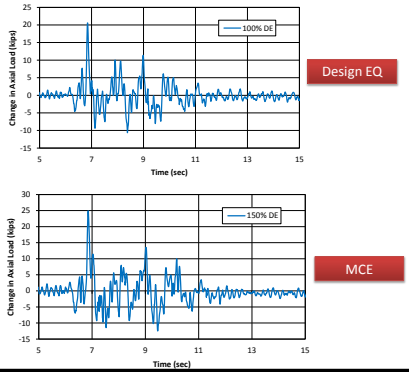


Superstructure Uplift at the Abutment

Superstructure Uplift at the Abutment



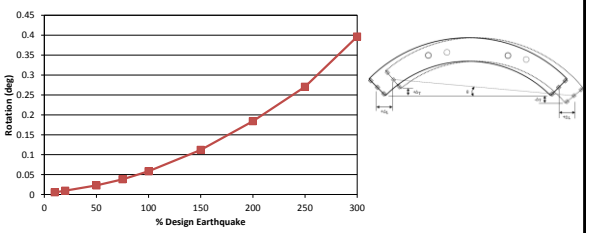
Fluctuation of Column Axial Load



Design EQ

MCE

Experimental Results
In-Plane Deck Rotation



Concluding Remarks

- Improving the seismic resiliency of infrastructure lifelines:
  - Development of tools to improve seismic performance of infrastructure lifelines
  - Better understanding of earthquake resistant design and construction
  - Development of technologies and measures for system-wide mitigation in new and existing infrastructure lifelines