

# SEISMIC ANALYSES OF FHWA EXAMPLE 6 BRIDGE: PEER REVIEW

---

Presented by:

Group 4  
Haque, A. B. M. Tahidul  
Khusaibi, Hazim-Al  
Krishnappa, Nagarjun  
Kumar, Manish (mkumar2)  
Kumar, Manish (mkumar3)

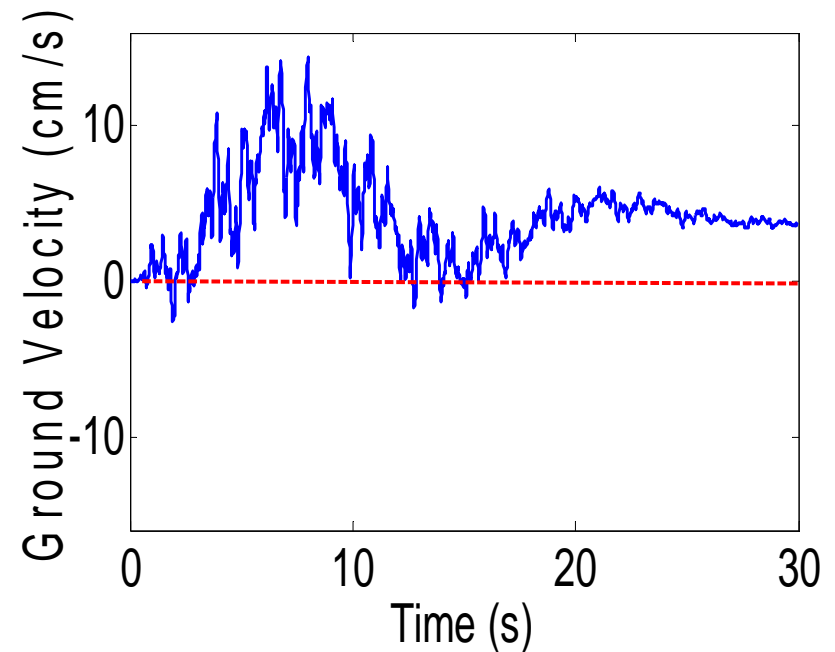
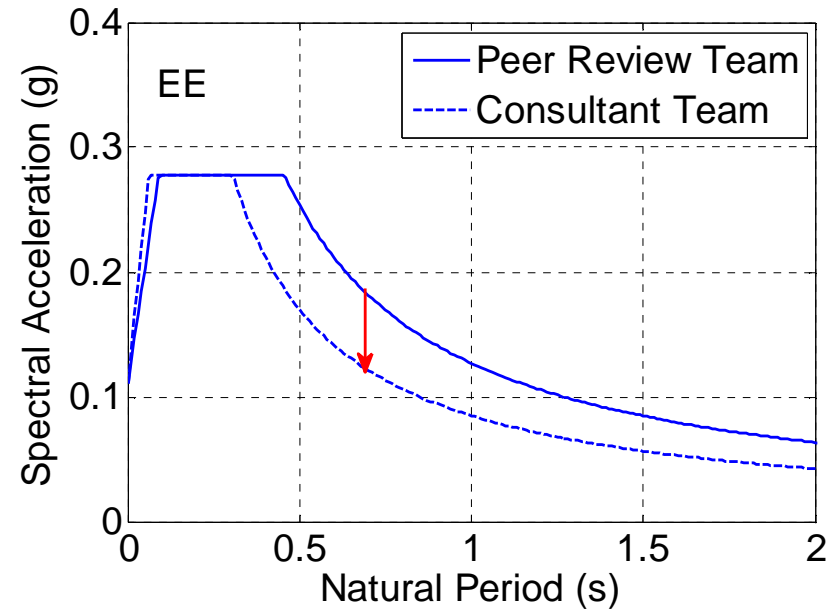


# KEY ISSUES

---

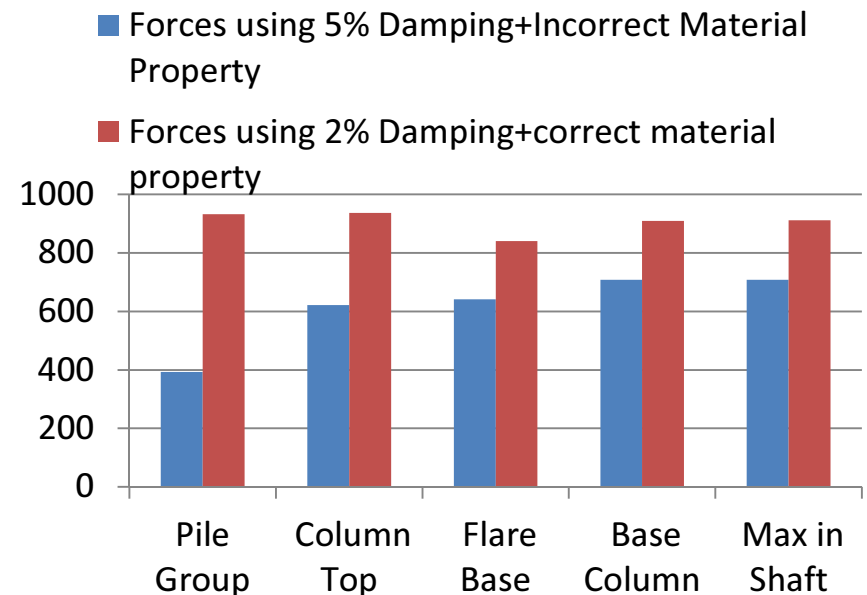
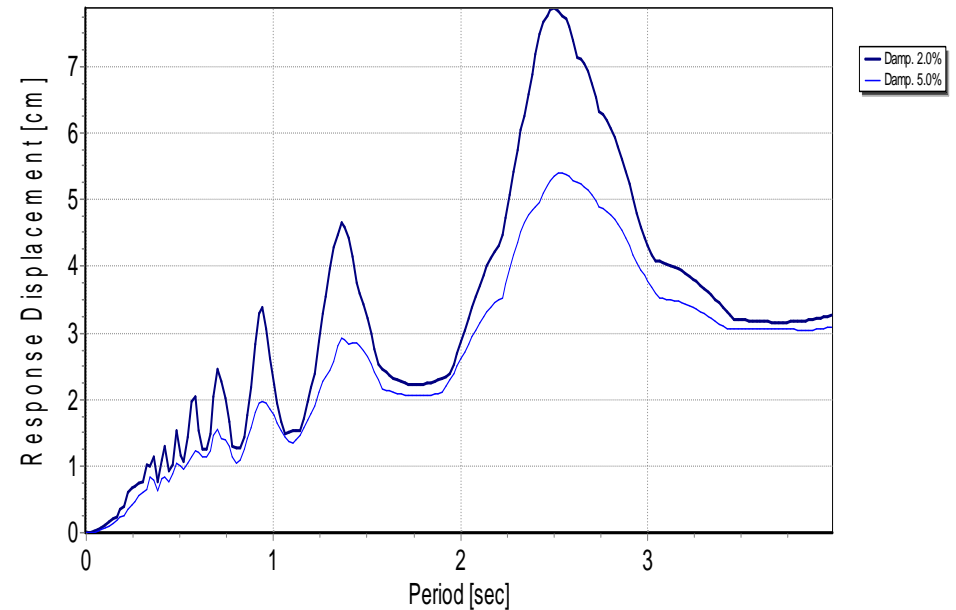
# Seismic Hazard

- Wrong value of  $F_v$  (1.6 instead of 2.4) for EE was taken
- Underestimation of Response Spectra for EE
- Leads to wrong selection of ground motions for EE
- Selected virtual ground motions were not checked for base line correction



# Damping

- 5% of critical have been used  
1.5-2% suggested for reinforced concrete bridge(Villaverde 2007)
- Proportionality constant were calculated by assigning 5% damping to periods 1 secs and 0.1 sec in Nonlinear Dynamic Analysis
  - Default SAP2000 values were used
  - 2% damping should be assigned to 0.69 sec(1<sup>st</sup> Mode) and 0.68 sec(2<sup>nd</sup> Mode)

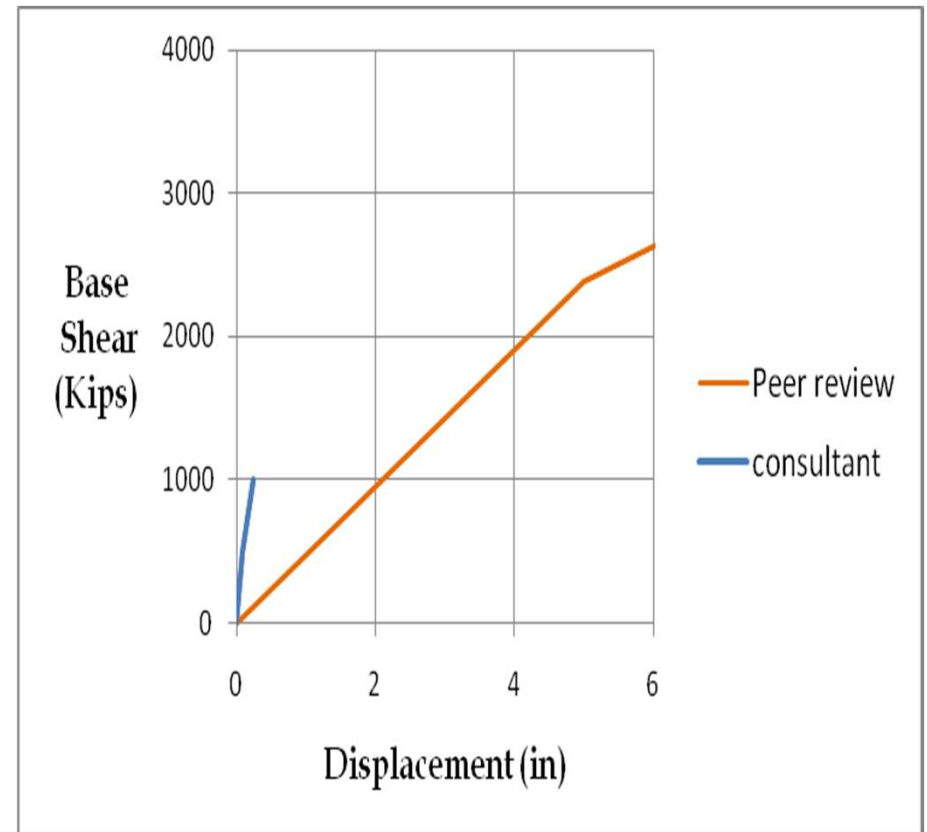


# Non Linear Hinges

- Incorrect material type of the rebar steel - A992Fy50.
- Incorrect Values of material properties
- The column has 22 rebar(instead of 30). Thus incorrect estimation of the moment capacity of the columns.
- Model validation of hinge - there is no mention of P-M2-M3 hinge.
- Pushover Analysis was redone by Peer Review Team

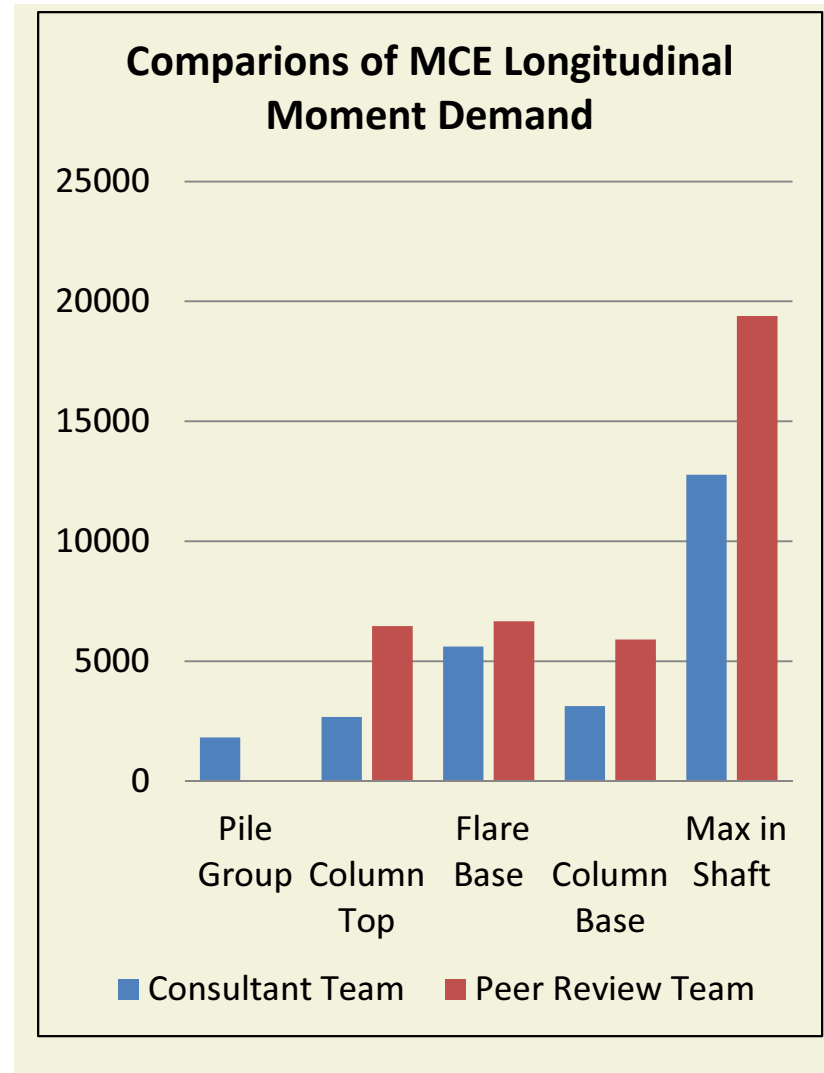
## Consultant Team's results

Maximum Base shear = 1000 kips  
Displacement at yield = 0.24 in



# Application of Ground Motion Data

- 100-40% rule used for Nonlinear Dynamic Analysis  
Applicable only for modal analysis
- Application of two orthogonal components of ground motions simultaneously to calculate the response
- Results were underestimated





# COMPARISON OF ANALYSES RESULTS

---

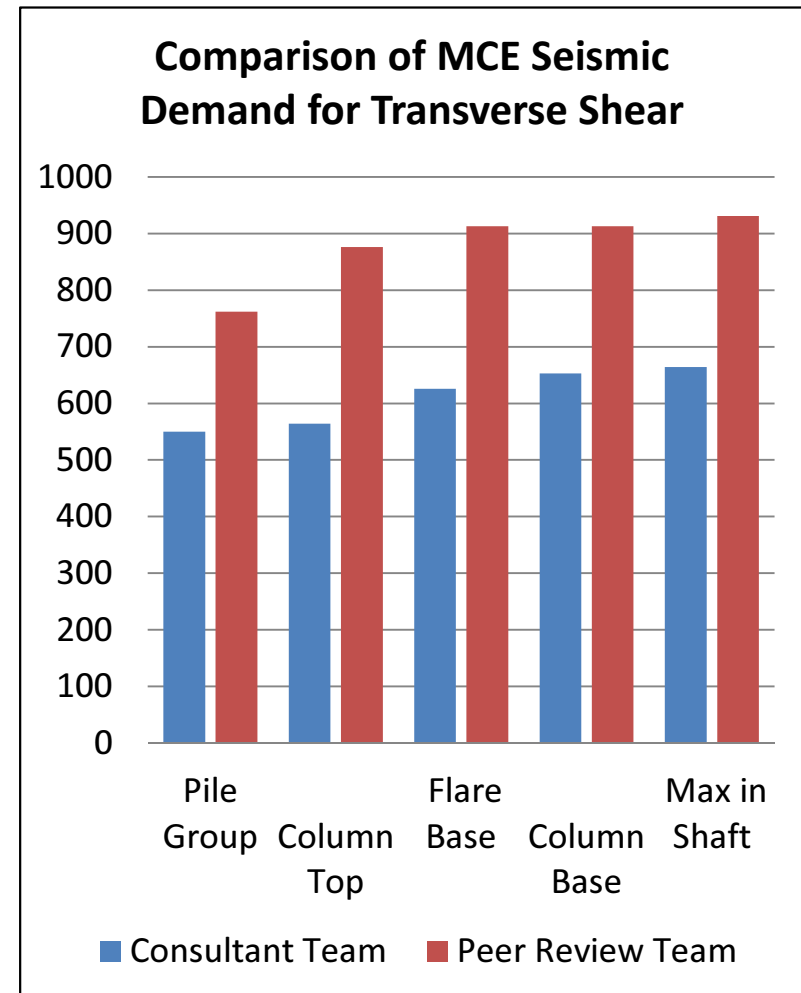
# Response Spectrum Method

- Consistent results for Uniform Load Method with Peer Review Team

Difference due to incorrect EE hazard

## Multimode Analysis

- 5% default damping was used
- Backfill stiffness was ignored
- Conservative demand on piers, but may not give good estimate of abutment forces
- Leads to underestimation of seismic demands





# Pushover Analysis

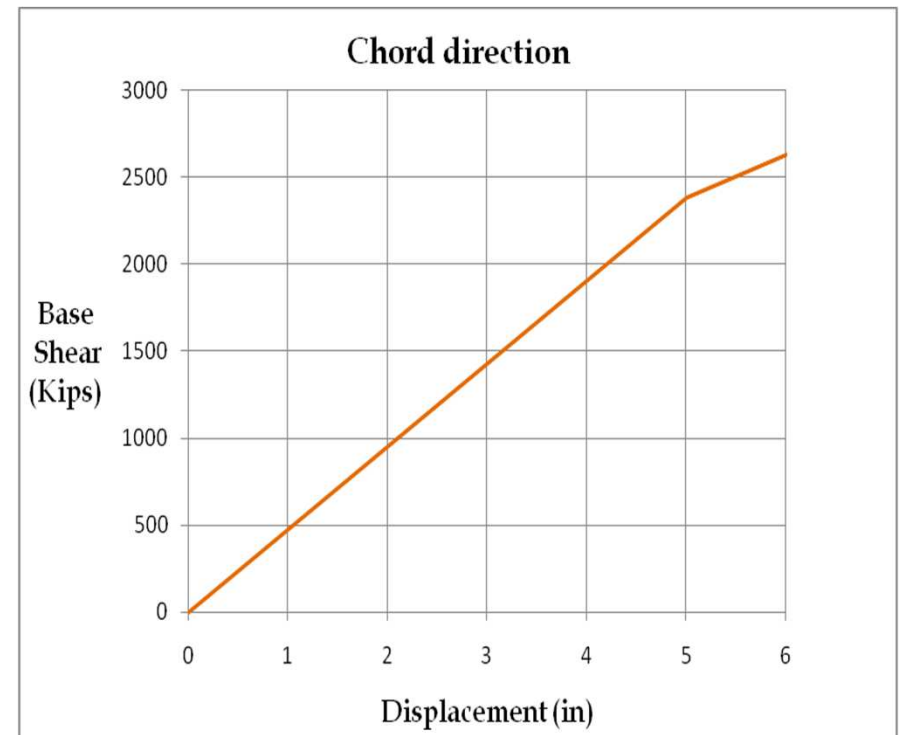
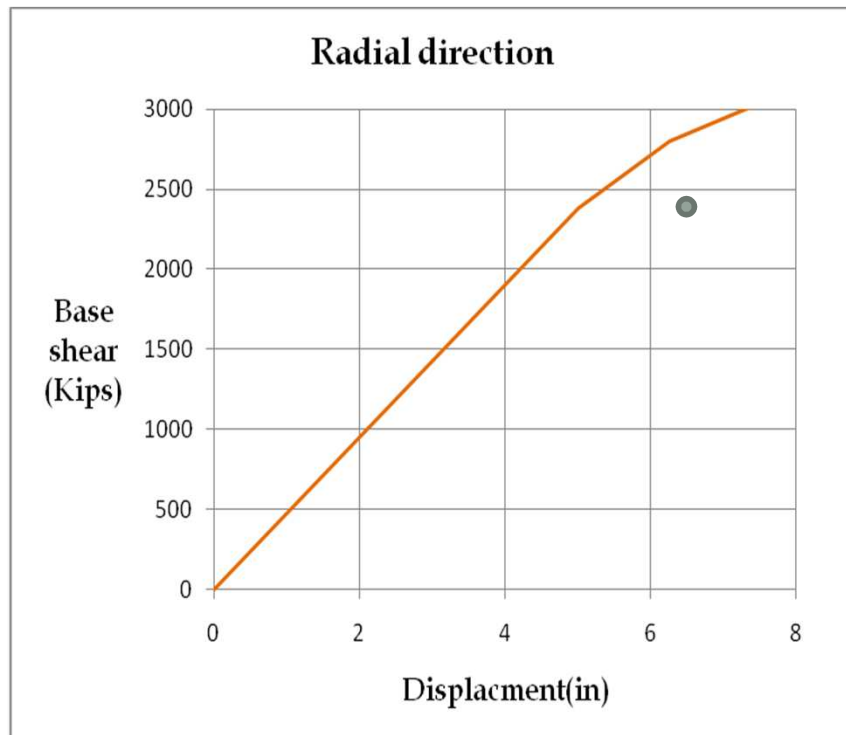
- No mention of detailed assumptions regarding cracked properties, lateral load pattern.
- Analysis done in single and unknown direction.

Chord direction

Maximum Base shear = 2384 kips  
Displacement at yield = 5.1 in

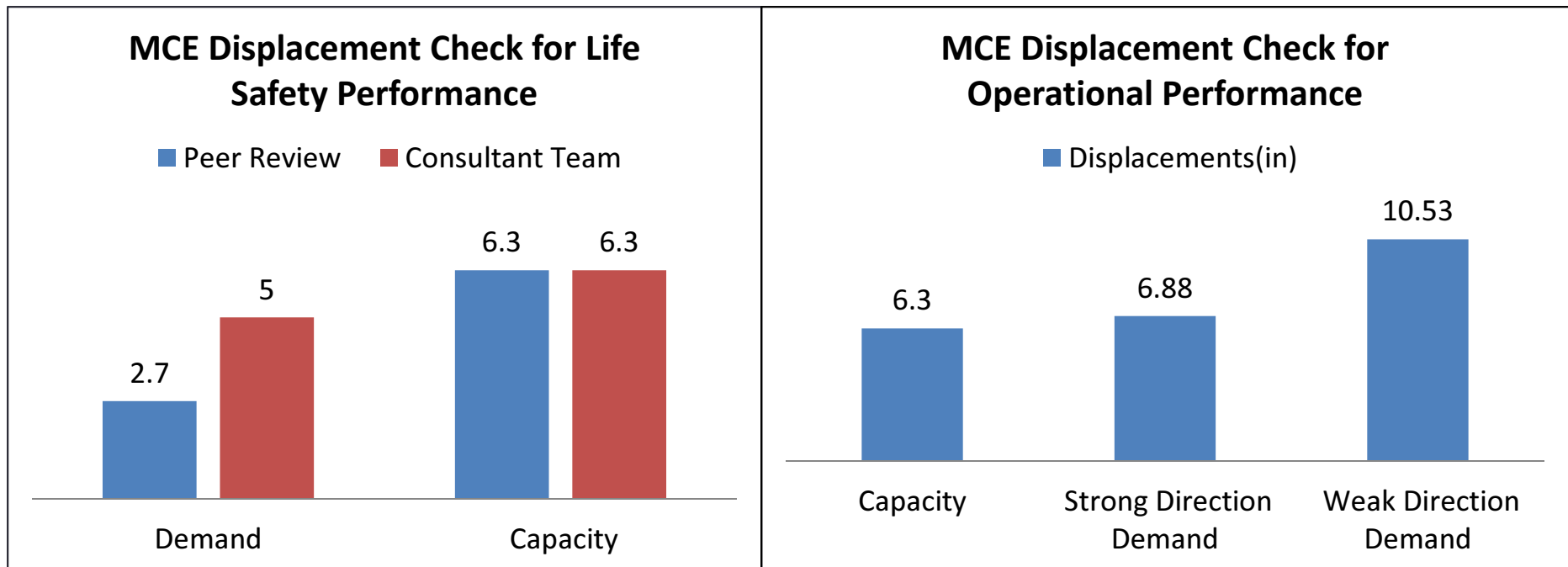
Radial direction

Maximum Base shear = 2831 kips  
Displacement at yield = 5.5 in



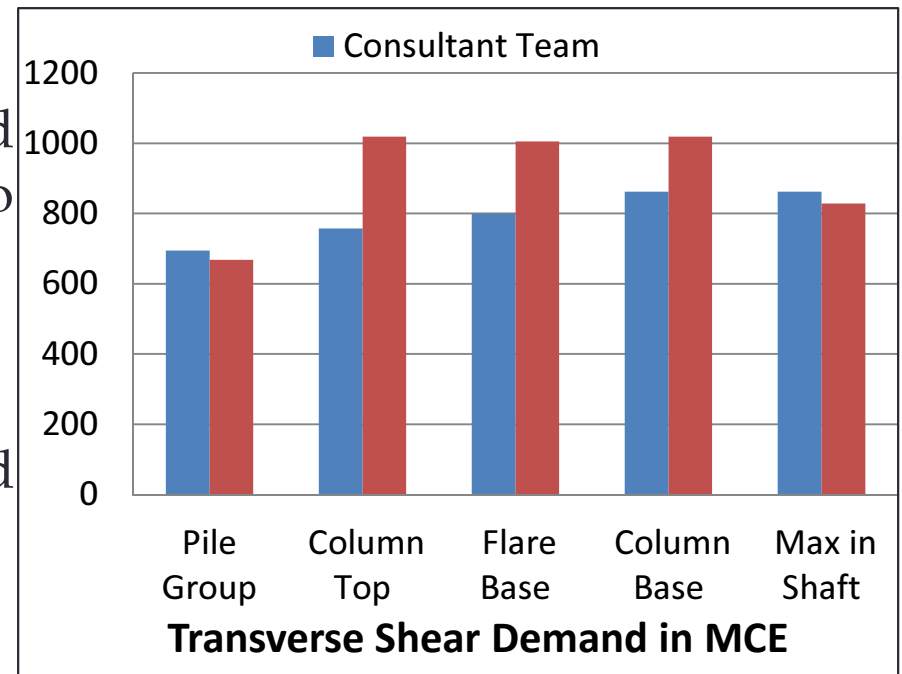
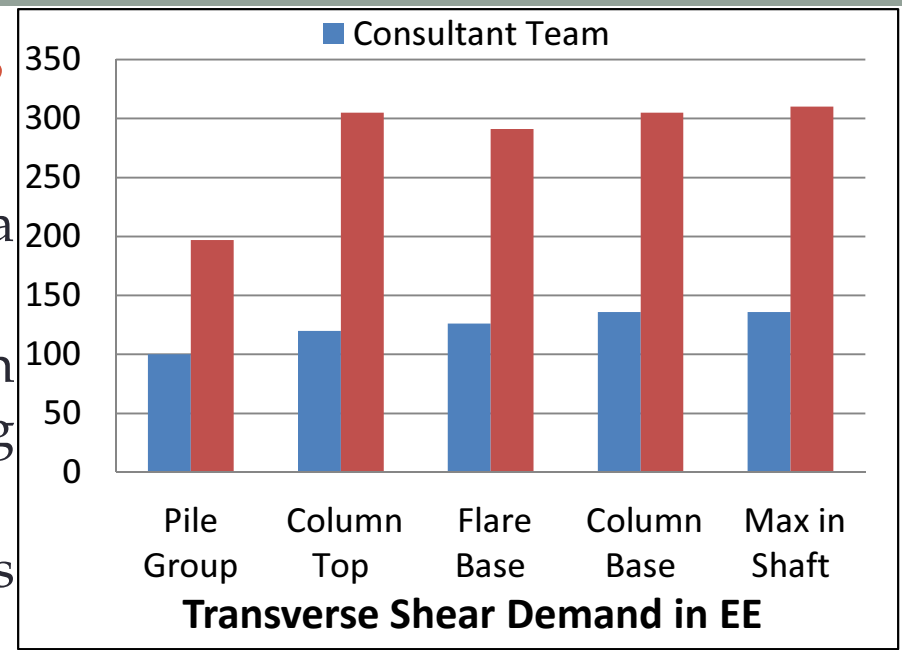
# Capacity Spectrum Analysis

- Only capacity in strong direction was checked.
- Yield displacement from pushover was taken with nonseismic shear capacity.
- Capacity spectrum figure presented using SAP2000 is only applicable for buildings according to ATC-40.
- Operational performance was neglected for MCE.



# Nonlinear Dynamic Analysis

- Underestimated Seismic Hazard for EE
- Excessive value of damping for a reinforced concrete bridge structure.
- Only one component of ground motion used and response was calculated using 100-40% rule
- Wrong values of material properties for Nonlinear Hinges
- Nonlinear Analysis was performed twice to show sensitivity with respect to
  - Damping and Material Properties
  - Selection and Application of Ground Motion
- Demands were calculated for EE and MCE



# Recommendations

- Correct Seismic Hazard for EE should be used
- Calculations should be done using 2% damping
- Nonlinear Hinges should be defined appropriately using correct material properties
- Ground motions should be selected from PEER ground motion database having strong and weak components
- Nonlinear Dynamic Analysis with application of strong and weak components of ground motion simultaneously
- Capacity of bridge should be checked in all the directions, for different performance criteria



**THANK YOU!**

---