A Systematic Computational Framework for Multi-span Bridge PBEE Applications

PEER Transportation Systems Research Program

Principal Investigators: Ahmed Elgamal (UCSD) and Kevin R. Mackie (UCF) Staff Investigator: Jinchi Lu (UCSD) Student Investigator: Abdullah S. Almutairi (UCSD)

Summary

A computational user interface (MSBridge) is developed to combine nonlinear Time History Analysis (THA) of multi-span bridge systems with an implementation of a PBEE methodology developed by the Pacific Earthquake Engineering Research (PEER) Center. OpenSees is employed to conduct Nonlinear THA.









MSBridge user-interface



Curved bridge with foundation of soil springs Bridge with different numbers of columns for bents (with Foundation stiffness matrix)

Visualization of plastic hinges

Mode shape analysis



Bridge Case Study

A straight, single column bents, box girder, reinforced concrete bridge with five spans is studied (bridge configuration from Ketchum et al. 2004).



FE model created in MSBridge

<u>Ground Motions</u> A set of 100 ground motions selected to be representative of seismicity in typical regions in California was employed in this study (Mackie et al. 2007). The motions are divided into 5 bins: i) moment magnitude (Mw) 6.5–7.2 and closest distance (R) 15–30 km (denoted LMSR bin), ii) Mw 6.5–7.2 and R 30–60 km (LMLR), iii) Mw 5.8–6.5 and R 15–30 km (SMSR), iv) Mw 5.8–6.5 and R 30–60 km (SMLR), and v) Mw 5.8–7.2 and R 0–15 km (Near bin).

Ground motion viewer

	Intensit	y Measure	s [
Intensity Measures of Motion Near\NORTHR\JEN					
Intensity Measure (IM)	Longitudinal	Transverse	Horizontal SRSS	Vertical	
PGA (g)	0.56996	0.98238	1.0441	0.67476	
PGV (cm/sec)	75.84	66.424	89.27	31.123	
PGD (cm)	42.362	22.559	42.365	14.696	
D(5-95) (sec)	25.68	25.38	25.6	27.66	
CAV (cm/sec)	1284.1	1655.5	2304.5	1173.1	
Arias Intensity (cm/sec)	308.05	621.46	930.76	283.97	
SA* (g)	0.56575	1.3051	0.92361	0.35944	
SV* (cm/sec)	101.54	190.16	81.143	58.771	
SD* (cm)	13.954	32.235	22.865	8.8956	
PSA* (g)	0.56176	1.2978	0.92051	0.35813	
PSV* (cm/sec)	87.673	202.54	143.66	55.893	

PBEE Outcomes Implementation of the PEER PBEE methodology by Mackie et al. (2010) is employed in this framework.

Bridge EDP Quantities	_ _ ×
EDP View Data Add Figure to Report	
150 -	► LMLR ▲ LMSR ※ Near SMLR + SMSR × LMLR ● LMSR ▲ Near ※ SMLR ■ SMSR

Damage States								. 🗆 X
mage States								
EDP	DS1 Lamda	DS1 Beta	DS2 Lamda	DS2 Beta	DS3 Lamda	DS3 Beta	DS4 Lamda	DS4 Beta
Max. Tangent Drift SRSS (%)	0.240587276	0.3	1.162432794	0.33	4.819153373	0.25	4.671089964	0.35
Residual Tangent Drift SRSS (%)	0.5	0.3	1.25	0.4	2	0.4	4.671089964	0.35
Max. Relative Deck-(Left) Abutment Long. Disp. (m)	0.0508	0.25	0.1016	0.25	0.110744	0.3	0.138176	0.3
Max. Relative Deck-(Right) Abutment Long. Disp. (m)	0.0508	0.25	0.1016	0.25	0.110744	0.3	0.138176	0.3
Max. Absolute (Left) Bearing Displacement	0.0765	0.25	0.153	0.25	0	0	0	0
Max. Absolute (Right) Bearing Displacement	0.0765	0.25	0.153	0.25	0	0	0	0
eft Approach (Residual) Vertical Displacement	0.073152	0.4	0.146304	0.4	0.3048	0.4	0	0
Right Approach (Residual) Vertical Displacement	0.073152	0.4	0.146304	0.4	0.3048	0.4	0	0
eft Abutment Foundation	0.0508	0.25	0.1016	0.25	0.110744	0.3	0.138176	0.3
Right Abutment Foundation	0.0508	0.25	0.1016	0.25	0.110744	0.3	0.138176	0.3
Column Foundation	0.080977926	0.4	0.135202351	0.4	0	0	0	0
OK								



4	PBEE Output	_ 🗆 X
- PBEE Outcome Contribution to	Plot View Data	
Expected Repair Cost from Fach PG		- mean

Ground motion intensity measures



Engineering demand parameters Performance Groups (PG) and

Repair cost

Disaggregation

- Plot View Data

26 % --

_ **D** X

PG 2

PG 11

RGIE

- 26 %

-0%



Repair cost ratio

PBEE analysis for a 2-span single-column bridge is available in BridgePBEE (peer.berkeley.edu/bridgepbee)



Damage states

0.001

0.0003

0.0001

Plot (Mean Annual Total Repair Time = 0.0355287 CWD) View Data

Total Repair Time (CWD)



Repair time

Repair time hazard curve

Disaggregation of repair cost by PG

Acknowledgment

Partial funding was provided by the California Department of Transportation (Caltrans). In addition, we are grateful for the valuable technical contributions provided by Caltrans engineers, particularly Dr. Mark Mahan, Mr. Steve Mitchell, Dr. Anoosh Shamsabadi, Dr. Charles Sikorsky, Mr. Yeo (Tony) Yoon, and Dr. Toorak Zokaie.

_ 🗆 X

This project was made possible with support from:

Disaggregation

Disaggregation of

Expected Cost

Disaggregation o

by Repair Quantity

Disaggregation of

Expected Time

by Repair Quantity

PGV = 150 cm/s

Expected Cost

by Performance Group



