University of Wollongong
Université de Sherbrooke

M. Neaz Sheikh
[2007 AEES conference]

The University of Hong Kong
The University of Melbourne

Co-authors
Frederic Legeron, Hing-Ho Tsang, Nelson T K Lam and Timothy J McCarthy

Earthquake Engineering for Transportation Network in Low to Moderate Seismicity Regions

Summary: In low to moderate seismicity regions, seismic resistant design is still considered complicated and expensive in terms of actual seismic risk. Moreover, in the design codes, economic factors have not been integrated fully with the design principles. Bridges are the most critical components of the transportation network and deserve proper consideration in terms of seismic risk. A systematic approach is proposed for evaluating the cost-effectiveness of existing bridge design codes from the perspective of lifecycle cost consideration. It is demonstrated that life cycle cost should be considered in the design phase of a new/retrofitted structure, and the target performance significantly depends on the expected average daily traffic.

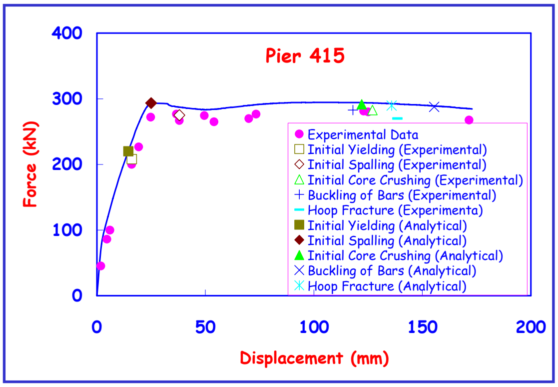
Objectives: The objective of this paper is to propose expected life cycle cost oriented approach to ascertain optimal seismic design of bridges based on economic principles.

Definition of Performance Limit States

Limit states (LS)	Operational performance level	Post earthquake serviceability	Qualitative performance description	Quantitative performance description	Repair
1A	Fully Operational	Full service	Onset of hairline cracks	Cracks barely visible	No repair
1B			Yielding of longitudinal reinforcement	Crack width <1 mm	Limited epoxy injection
2	Delayed Operational	Limited service	Initiation of inelastic deformation; onset of concrete spalling; development of longitudinal cracks	Crack width 1-2 mm ϵ_c=-0.004	Epoxy injection; concrete patching
3	Stability	Closed	Wide crack width/ spalling over full local mechanism regions; buckling of main reinforcement; fracture of transverse hoops; crushing of core concrete; strength degradation	Crack width>2 mm $\epsilon_{c=}\epsilon_{cc50}$ (initial core crushing) ϵ_c=ϵ_{cu} (fracture of hoops) ϵ_s<0.06 (longitudinal reinforcement fracture)	Extensive repair / reconstruction

e_c =axial strain of concrete; e_{cc50}=post peak axial strain in concrete when capacity drops to 50% of confined strength; e_{cu}= ultimate strain of concrete; e_s=tensile strain at fracture

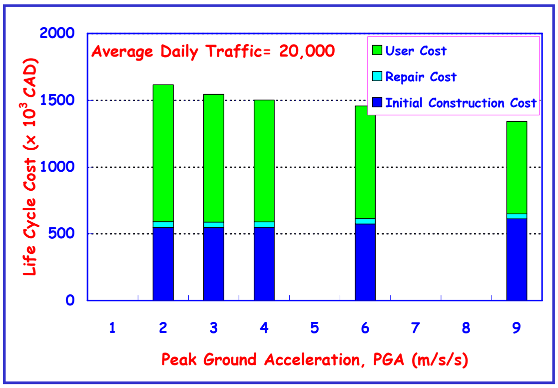
Analytical Modelling: Experimental Result compared with Analytical Prediction

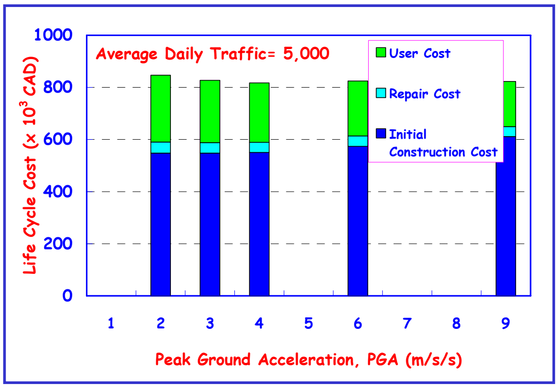


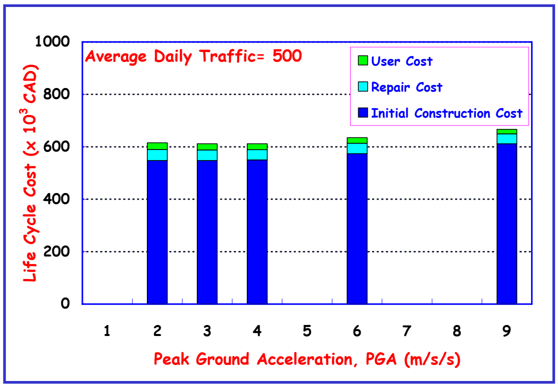
Life Cycle Cost of Analysis of a Two-Span Bridge:

A simple two-span bridge in Vancouver; Design peak ground acceleration 0.3g, Span length= 20 m, Supported by 9 m high pier, Superstructure unit weight= 150 kN/m. A 11 km detour will be required for the 1 km of roadway in which the bridge is located.

Life Cycle Cost of a Two-Span Bridge







Conclusions:

A systematic approach is proposed for the optimal seismic design of bridges considering life cycle cost, based on performance limit states that can be related directly to the functionality and repair cost.

Life cycle cost of a bridge depends largely on the user cost. If the bridge is located in a busy roadway, it is economical to design the bridge for a higher level of earthquake ground motion