INTRODUCTION

New Zealand is a seismically active country, and the effects of earthquakes on infrastructure can be significant. The New Zealand distributed infrastructure network has little or no redundancy throughout the country. With the reliance on transport networks for essential services, it is critical to ensure the network remains functional after a seismic event. Bridges are a key part of the road network, and yet there are currently many unknowns related to the actual seismic response. On top of that, there has been an absence of systematic cataloging of the seismic demand and performance across historic earthquake in New Zealand. The objective of this study is to assess the performance of NZTA state highway bridges in historic earthquake in New Zealand.

SEISMIC BRIDGE DESIGN STANDARDS IN NEW ZEALAND

Bridge design in New Zealand has been controlled by a centralized organization until it was privatized in 1988. The New Zealand Transport Agency (NZTA) currently manages the operation of the State Highway network. Seismic bridge design standards have been developed along with the changes in the organizations controlling the design and construction. These standards, published by NZTA and its preceding organizations, defined the requirements for traffic, wind, flood, temperature and seismic loading. The development of bridge design standards in New Zealand can be classified into six eras.

THE NEW ZEALAND HIGHWAY BRIDGE STOCK

There are approximately 2700 highway bridges on the State Highway network in New Zealand that are managed by the NZ Transport Agency.

HISTORIC BRIDGE DAMAGE CLASSIFICATION

Bridge damage from historic earthquakes was defined based on details collated from post-event reconnaissance report, commissioned reports and journal articles. The level of detail describing the observed bridge damage from these sources varies according to the age of the earthquake, with information from recent earthquakes being more detailed than that from older earthquakes. Damage descriptions were mostly qualitative, and relate to either structural and/or geometrical damage. Due to the differences in damage descriptions used across different reports, there will be some uncertainties in the classification, therefore a qualitative approach was used. Damage severities were classified into three categories, none – minor, moderate and major.

Classification of Damage Severity

- None – minor
  Damage does not affect structural integrity and no loss of bridge functionality
- Moderate
  Damage results in some loss of structural integrity and/or limited reduction of functionality
- Major
  Damage results in loss of structural integrity and/or loss of functionality

COMPARISON WITH SEISMIC SCREENING

Seismic screening has been initiated since the late 1990’s to assess the seismic performance of State Highway bridges across New Zealand. As part of the screening process, PGA that may potentially result in severe damage in seismic events were estimated for bridges across New Zealand. Out of the 824 bridges, 264 bridges had a Screening PGA assigned as part of the seismic screening process. The Event PGA at the bridge sites were compared with the Screening PGA. Only structural damage were considered as it is the main focus of the screening process. Each point in the figure represents a bridge. Based on this comparison, there is little evidence of poor bridge performance based on this comparison.

CONCLUSION

- 824 occurrence with PGA higher than 0.05g, mostly distributed along the eastern to the southern part of North Island and northern part of South Island
- Three quarter of bridge stock experienced PGA < 0.3g
- Number of bridges with moderate and major damage is relatively small.
- Performance of bridges in terms of structural and geotechnical aspects was generally good across all events considered

- Based on comparison with the NZTA seismic screening results, there is little evidence of poor performance of any bridge typologies
- Some shorter bridges may have performed better because many were effects of abutment damping
- Longer bridges might have performed better due to travelling waves effects that result in a phase lag between the seismic input motions at the piers along the length

APPROACH

To assess the historic seismic performance of the bridge stock across a range of earthquake magnitudes, the following steps were undertaken:

1. Characterization of seismic demand at each bridge location through geostatistical interpolation of recorded and felt data
2. Classification of bridge damage severities
3. Collation of historic bridge performance and comparison of the performance with NZTA seismic screening

HISTORIC SEISMIC DEMAND AT BRIDGE SITES

In this study, the focus was on the performance of the bridge stock during the earthquakes that have occurred in the last 50 years in New Zealand. The ground motion intensity at each bridge location for these 10 earthquakes was defined using PGA contours from the United States Geological Survey (USGS) earthquake catalogue. The PGA at each bridge location, termed event PGA in this study, was approximated using the empirical Bayesian Kriging interpolation in ArcGIS.