Quantifying the Vulnerability of Vermont Bridges to Seismic Loading

The University of Vermont

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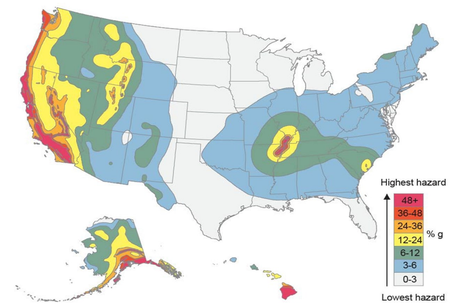
Project Motivation

Quantifying seismic vulnerability of Vermont's bridges is vital for managing the state's transportation system to improve disaster resilience and enable appropriate fiscal planning for transportation assets. Quantifying seismic vulnerability is hampered by:

- **The overall quantity of bridges (over 2,800).**
- **The knowledge and effort required for the quantification.**
- **The degree of deterioration present in each bridge.**
- **The continually changing condition of the inventory.**
- **Limited guidance available suitable for low to moderate seismic regions, and for older deteriorated bridges.**

1,000 year Return Period Seismic Hazard



Map Source: Congressional Research Service Report "Earthquake Risk and U.S. Highway Infrastructure: Frequently Asked Questions, June 5, 2013, (Map by U.S. Geological Survey (USGS), March 2011, with minor formatting changes made by CRS).

The USGS indicates northwestern Vermont has the fifth highest seismic hazard potential in the continental U.S.

Vermont's seismic hazard results from seismicity in the St. Lawrence River valley region in Canada.

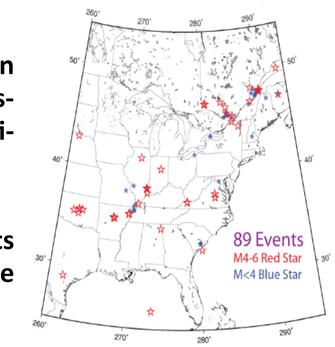


Figure 2.1 Central and Eastern North America earthquakes selected for inclusion in the NGA-East ground motion database. The 1929 Grand Banks and 1985 Nahanni earthquakes are off this map and hence not shown.

Methodology for System-Wide Vulnerability Screening

Bridges A and B bracket the predominant span lengths and column heights of most Vermont multi-span bridges.

	Pier Height, Feet				
Span Length, Feet	**15**	**20**	**25**	**30**	**35**
30	0.14	0.21	0.29	0.38	0.48
40	0.15	0.23	0.32	0.42	0.52
50	0.17	0.25	0.35	0.45	0.56
60	0.18	**0.27**	**0.37**	**0.48**	0.60
70	0.19	**0.28**	**0.39**	**0.51**	0.64
80	0.20	**0.30**	**0.41**	**0.54**	0.68
90	0.21	**0.32**	**0.43**	**0.57**	0.71
100	0.22	**0.33**	**0.45**	**0.59**	0.74
110	0.23	**0.34**	**0.47**	**0.62**	0.77
120	0.24	**0.36**	**0.49**	**0.64**	0.80
130	0.24	0.37	0.51	0.66	0.83
140	0.25	0.38	0.53	0.68	0.86
150	0.26	0.39	0.54	0.71	0.88

Augment screening with non-linear finite-element seismic modeling of 70 ground motions on two bridges for pristine and spalled concrete bents for multiple girder bridges, which comprise 80% of the multi-span bridges.

NBI data with Vermont supplemental notation

Simple Spans

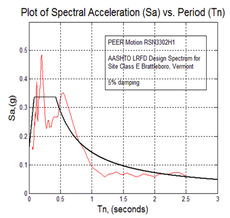
Two-girder

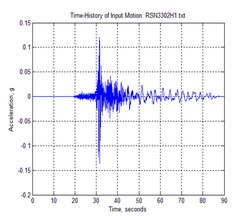
Skewed

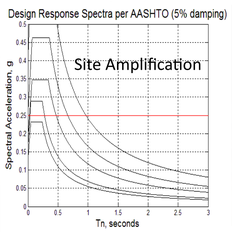
Unstable Bearings

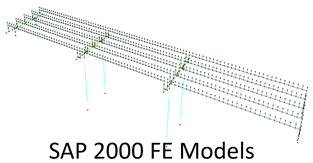
Screen inventory for seismic vulnerability characteristics

Seismic Vulnerability Rating - Multiple Span Bridges



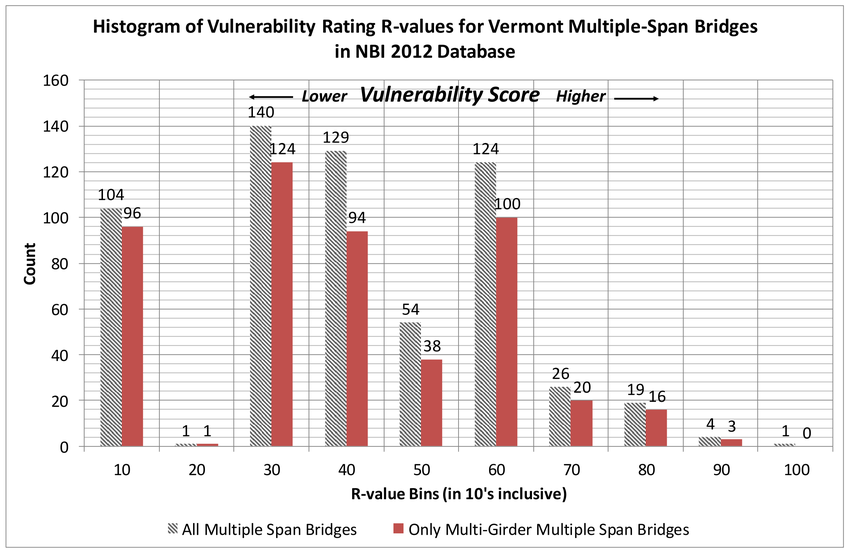






SAP 2000 FE Models

Vermont Rapid Seismic Screening Algorithm (VeRSSA) created in this study



Bridge vulnerability depends most on geographic location, soil type, and bridge features.

The higher vulnerability bridges tend to be multi-span, non-continuous span bridges in north-western Vermont.

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