DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Benchmarking Bridge Pile Performance

Data from recent earthquakes helps refine design procedures for bridge pile foundations

Seismic

NOVEMBER 2014

Project Title:
Benchmarking Recently Developed Procedures for Designing Pile Foundations in Laterally Spreading Ground

Task Number: 2421

Start Date: November 30, 2011

Completion Date: July 31, 2014

Task Manager:
Charles Sikorsky
Research Program Manager
charles.sikorsky@dot.ca.gov

WHAT IS THE NEED?

Caltrans has been developing procedures for estimating pile performance during lateral spreading events. Recent earthquakes in Japan (2011), Chile (2010), and New Zealand (2010 and 2011) provide case studies of earthquake-induced damage that are relevant to California. The earthquakes occurred in economically viable countries with advanced seismic engineering codes comparable to California. Comparing bridge design specifications to actual performance during seismic events will help confirm the accuracy of the new procedures and reveal areas that need improvement.

WHAT WAS OUR GOAL?

The goal is to benchmark recently developed procedures for designing pile foundations in liquefaction-induced lateral spreading.

WHAT DID WE DO?

Caltrans, in partnership with Oregon State University, analyzed and compared the performance of three bridges during recent earthquakes: the Mihama Bridge in Japan, the South Brighton Bridge in New Zealand, and the Mataquito Bridge in Chile. The researchers first calculated each bridge's pile performance before the earthquake—as an engineer would when initially designing the bridge. The predictions were then compared to observed bridge pile performance as result of the seismic events to check the applicability of the design guidelines and benchmark the procedures in the areas of ground displacement and pile damage by bending moments.

WHAT WAS THE OUTCOME?

Based on the information available, the benchmarking produced a number of recommendations. However, to ensure accuracy, the researchers need more comprehensive data sets with soil information, structural details, earthquake recordings, and damage assessment. Since starting the comparisons, more data from the three earthquakes has become available, which could expose weaknesses in the current procedures and lead to more robust analysis methods. The procedures work well for small bridges with modest pile groups. For larger pile groups, the assumption of a "super pile" is problematic.

WHAT IS THE BENEFIT?

Much can be learned by assessing real-world examples of seismic events. The initial comparisons between the computed and observed performance of the bridges highlight potential refinements to the Caltrans design procedures. Based on these three case studies, the current Caltrans method performs reasonably well, but more benchmarking efforts should be carried out to further confirm the strength of the Caltrans method.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2014/CA15-2421_FinalReport.pdf

IMAGES

Bridge	Estimated ground displacement (cm)	Estimated pile head displacement (cm)	Observed ground displacement (cm)	Observed abutment displacement or deflection (cm)
Mataquito Bridge, Chile	4–10 (PGA = 0.461) 3.5–8 (PGA = 0.390)	1.5–6.1	N/A	Less than 2 cm -20 cm
South Brighton Bridge, New Zealand	11–20	10–20	N/A	N/A
Mihama Bridge, Japan	4–13.5	3.2–7.4	1–18	

Comparison of estimated bending moments			
Bridge	Estimated maximum bending moment (kN-m)	Yield bending moment (kN-m)	Allowable bending moment (kN-m)
Mataquito Bridge, Chile	38,099–55,815	45,000	62,920
South Brighton Bridge, New Zealand	2,186–2,204	1,200	2,200
Mihama Bridge, Japan	75,083–119,154 (using estimated ground displacement) 77,245–131,014 (using observed ground displacement)	130,000	161,258

Figure 1: Comparison of estimated displacement with measured bridge displacement and comparison of estimated bending moments