Modelling of Bridge Pile-Column Field Test Response

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Motivation
Soil-foundation-structure interaction (SFSI) is an important aspect in the assessment of the seismic response of bridges and buildings, however there is debate as to its effect on overall system response. The main reason to lack the understanding especially, in design perspective, is the lack of in-service data related to nonlinear stiffness and damping behaviour of pile foundations, as limited full scale pile tests have been performed to date. The main objective of this study is to understand SFSI in pile foundations under static and dynamic loading conditions.

Field Testing of Piles
Henderson Creek Bridge No. 2, which is located on State Highway 16 (SH16) in Auckland, was designed using low seismic provisions and was constructed in 1962. This bridge was a five span reinforced concrete structure with an overall length of 93m and width of 9.35m. The superstructure of this bridge was supported by four 0.91m dia column RC piers, which were extended below ground as pile foundations. An opportunity to conduct a large scale foundation tests occurred during the reconstruction of this bridge.

Test Setup
At the top of pier a steel frame was hooked over and bolted on to pier cap. This neighbouring pier acted as a reaction frame, through which the lateral force was applied on to the test pier using hydraulic jacks and post tensioning strands. Each pile test was performed in two stages 1) Static Pushover stage – here the load is applied slowly until a maximum load 2) Snapback stage – the load is released at the maximum load, allowing the pile to undergo free vibration to rest. Multiple pushover and snapback tests were performed on the test pile over a range of maximum load levels. The pushover and snapback test results of only Pile-1 are presented here.

Field Test Results
The static pushover and snapback results are presented in Figure 3-6. The key points from the results are:
- There was reduction in soil stiffness with increasing loading levels, approximately a 25% reduction of secant stiffness between tests performed to same load levels before and after maximum loading.
- Time period of Pile 1 was varying between 0.19 s to 0.21 s.
- The damping ratio of Pile 1 is between 3 to 4% at 50kN load increasing to 10% above 150kN.
- Damping ratios for similar loading levels were observed to be similar and unaffected by the loading history.

Conclusions
- OpenseesPL models were able to match the static pushover and dynamic snapback responses of Pile 1 well.
- An increase in both period and damping ratio was observed with increasing load levels.
- A reduction in soil stiffness and an increment in soil nonlinearity was observed with increasing load levels.

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