MODELLING THE DYNAMIC RESPONSE OF WHIROKINO VIADUCT

SUBHECHHA SHARMA, LIAM WOTHERSPOON, LUCAS HOGAN

THE UNIVERSITY OF AUCKLAND

1. MOTIVATION

New Zealand has many long viaducts (Figure 2) constructed back when seismic design provisions were not accounted for during design and construction phases. A study of such structures can present a unique dataset for researchers for understanding the behaviour of these bridges that are on critical transportation networks. This research aims to capture the key parameters controlling response of the 82 years old Whirokino Viaduct through dynamic field testing and numerical modelling.

2. BRIDGE DESCRIPTION

Whirokino Viaduct was located over the Manawatu River floodplain on the state highway (SH1) south of Foxton in the lower North Island of New Zealand (Figure 1). It was recently decommissioned as it was nearing its economic life and required much maintenance works to hold up with the safety standards.

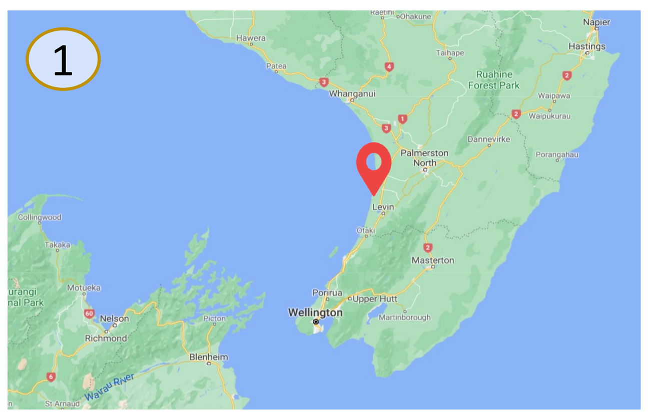

Figure 1: Location of Whirokino Viaduct

Construction Year:	1938
Length:	1097 meters long
Type:	Cast in-situ reinforced concrete bridge
No. of Spans:	90 [each 12.192 meters long]
Road cross-section:	Two 3.5m wide lanes and 0.16m wide shoulders
Structure:	Four T-beams per span (bottom reinforcement of 28 mm diameter and top reinforcement of 16 mm diameter, including 20 mm diameter stirrups) resting on columns reinforced with 20 mm diameter inclined long bar, along with 10 mm diameter transverse rebar (Figure 4,5)
Foundation:	9.14 m driven reinforced concrete piles reinforced with eight 22 mm diameter rods running along the length (Figure 8, 9)

During the maintenance works done on the bridge, a stop-bank (Figure 3) had been added at the midspan of 42nd and 43rd pier bent of the bridge.

Figure 2: Longitudinal View

Figure 3: Stop bank

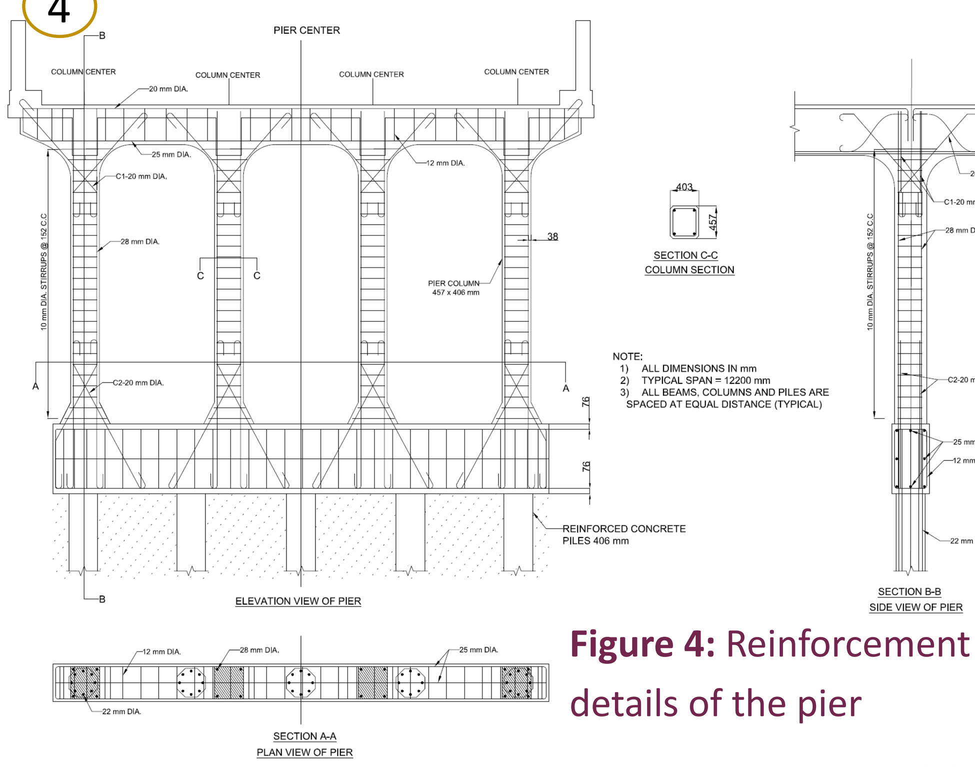

Figure 4: Reinforcement details of the pier

Figure 5: Pier bent

Figure 6: Northern Abutment

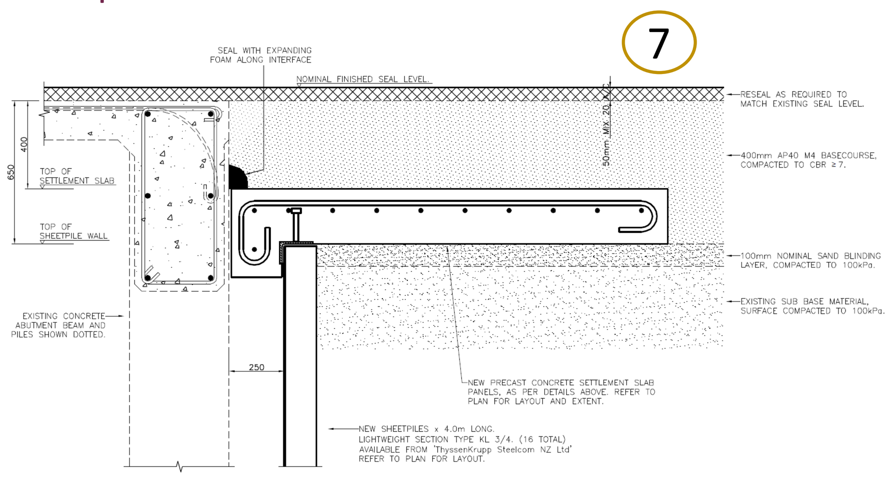

Figure 7: Settlement Slab

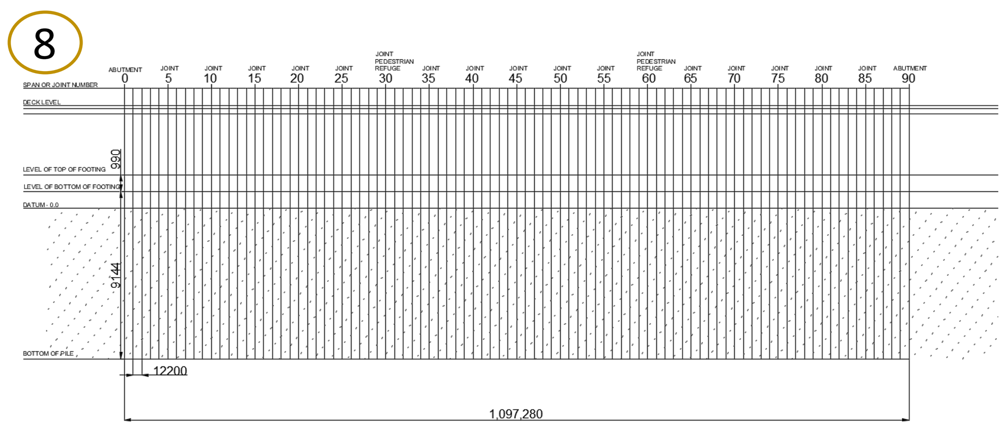

Figure 8: Longitudinal Section

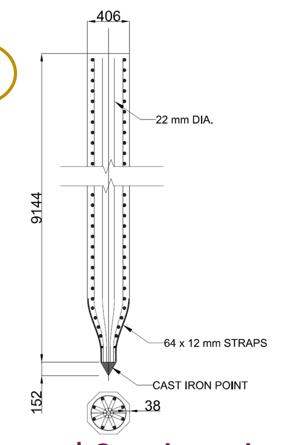

Figure 9: Plan and Section view of a typical 16' octagonal pile

3. FIELD TESTING

- To understand the insitu condition of the viaduct and its dynamic behavior
- 20 triaxial accelerometers were installed along its length powered by battery sources, and attached to the bridge kerbs using concrete anchors drilled onto the kerb (Figure 10,11).
- Ambient vibration data were collected for two recording periods, first when the bridge was fully intact (Figure 12), and second with several spans at the southern end removed (Figure 13).
- The data aids for an assessment of the effects of the abutment on the dynamic response.

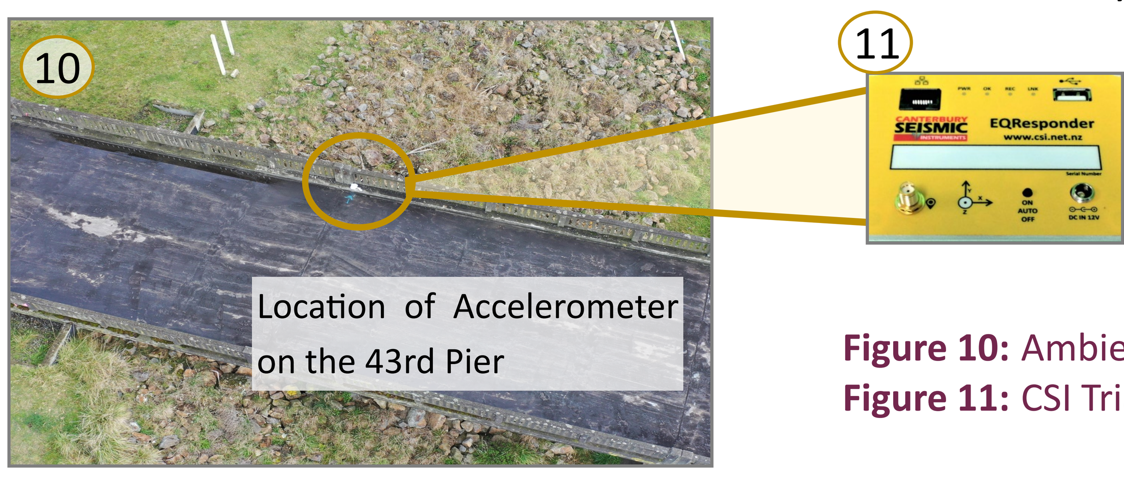

Figure 10: Ambient Field Testing
Figure 11: CSI Triaxial Accelerometer

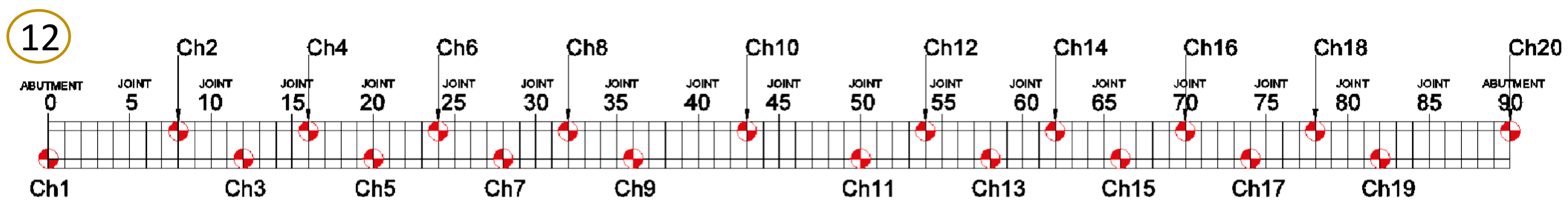

Figure 12: Location of sensors - Whole bridge intact

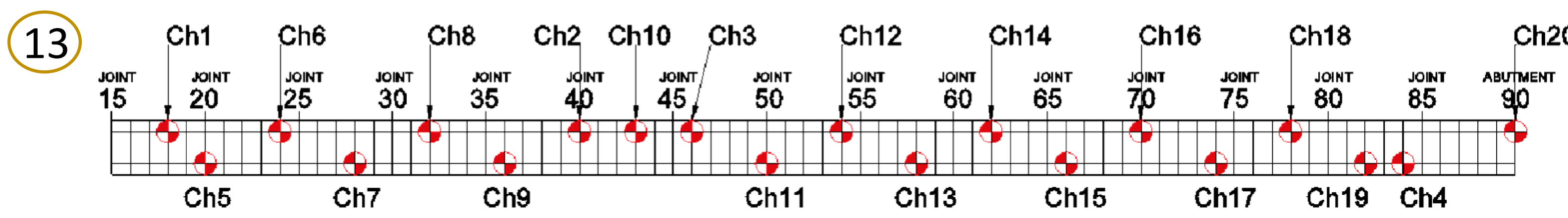

Figure 13: Location of sensors - After partial demolition

- Input parameters are unknown for ambient vibration testing, so it was followed by output-only modal parameter identification techniques for modal analysis.
- Modal Parameters Identification Toolbox developed at The University of Auckland is being used and System identification is being carried out to obtain fundamental period of both the whole and partially demolished bridge structure.

4. NUMERICAL MODELLING

- To use available characteristic details on the bridge, to capture its closest structural system, and then, identify the key parameters controlling its response
- 3 dimensional, 6 degree of freedom spine model was developed using OpenSeesPy
- Input parameters were derived & assumed from available design drawings and geotech. data
- Models were developed for different complexities—Single element fixed base model to 3D multielement representation of pier (Figure 14) and configurations — Whole bridge and partial.

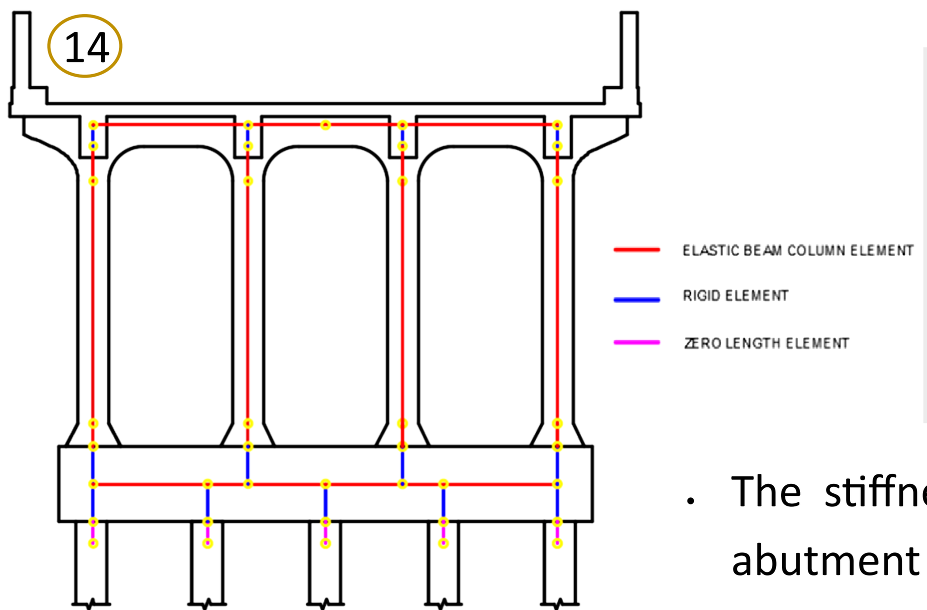

Figure 14 : Pier Model

The bridge elements were modelled as follows:

- Superstructure: Spine model with gross sectional properties
- Pier columns and beams: 'Elastic beam column' elements
- Foundations and soil: 'Uniaxial elastic zero length spring' elements

- The stiffness of topmost soil at the foundation of pier, abutment and backfill are considered for the model and later varied to observe its effect on the model.

5. PRELIMINARY MODELLING RESULTS

- The structural model obtained was run through Eigenvalue analysis and the bridge fundamental periods were obtained.
- Fundamental Period of the bridge when fully intact, To = 0.232 s

- To explore the response of bridge with restriction due to presence of stopbank, the fundamental period for half of the bridge was as well calculated, T_0= 0.258 s.

6. RESEARCH IN PROGRESS

The modal characteristics obtained through the field testing shall be compared with that derived through numerical modelling. The dynamic response of the model shall be observed for the following changes and updated accordingly,

- Input parameters: Soil stiffness along bridge length, change in material properties, boundary conditions
- Configuration: Change in length, presence or absence of stopbank, abutment type

7. CONCLUSION

It is hoped that the outcomes of this study will improve the understanding of the in-service response of bridges and inform design assumptions related to the contribution of different bridge components to overall dynamic response.