ORMOND EARTHQUAKE — 10 AUGUST 1993 REPORT ON VISIT TO EXAMINE THE EFFECTS ON BRIDGING

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INTRODUCTION

The earthquake which shook Gisborne at 21.46h on 10 August 1993 was reportedly alarming to local residents and was felt widely across the North Island. The event is described separately in more detail in this Bulletin. Briefly, the earthquake has been preliminarily assigned a magnitude of M_L 6.4 with a focal depth of 70 km. The epicentre was located 20 to 25 km north of Gisborne. Reports from the area were of only light building damage, and of bridging generally experiencing few problems, except that single lane traffic operations were necessary on two state highway bridges for a period after the event.

OBJECTIVES

The objectives of the inspection were:

- To examine the effects of the shaking on bridges, and also to look for instances where the effects of response to the shaking were apparently less than might have been expected.
- To investigate if the bridge responses evidenced would be helpful for the current seismic assessment project being undertaken by Transit New Zealand. This project comprises the development of "coarse sieve" guidelines with which the bridge stock can be prioritised for seismic assessment.

SCOPE OF INSPECTION

The author visited the area from August 16 to 18. Nineteen bridges were examined in some detail. In addition all state highway and district council bridges had been inspected in the hours following the event, as part of the normal maintenance procedures for the structures following an earthquake. The reports from these inspections were added to those assembled from the visit. Due to time constraints on the visit it was necessary to select bridges thought more likely to display interesting seismic behaviour. The longer or higher structures on a route were therefore given priority, although shorter structures were included when convenient. Bridges in the following areas were visited:

- along State Highway 2 between Wairoa and the Waihuka River, 30km northwards from Gisborne, and two other bridges on State Highway 38 in the Wairoa area.
- along State Highway 35 from Gisborne to the Pakarae River, 40 km to the north-east.
- all the main river bridges in Gisborne
- two Gisborne District Council bridges in Te Karaka, 25km north west of Gisborne, close to the epicentre.
- three small river footbridges carrying services across the Taruheru River in Gisborne.

OBSERVATIONS

The most noticeable aspect of the observations, in view of the significant ground accelerations and peak spectral accelerations, was the surprisingly small amount of visible evidence that the earthquake had shaken the structures. In many cases no evidence was visible - even such as results of small displacements at deck joints. At others such minor effects were visible. The following bridges did show more than minor effects:

- Waipaoa River Bridge - State Highway 2, 10km west of Gisborne.

  The bridge was built in 1956 and comprises structural steel I girder spans as follows, with five beams per span:

  6 x 12.1, 21.1, 7 x 25.2, 21.1, 3 x 12.1 metres.

  The main spans are continuous over the piers with cantilevers, and half-joints at span quarter points in alternate spans. Alternate joints are detailed to be "fixed" and "sliding", while all the short approach spans are "fixed". All the main span half joints are tied longitudinally with linkage bolts. The bridge carries two traffic lanes and a footpath, plus a 550mm diameter water main and a service duct beneath the footpath, covered with precast concrete slabs.

  Traffic across the bridge was restricted to the upstream lane for a week, due to local damage around the holding down bolts of three of the five bearings supporting the eastern end of the eastern main span. Damage comprised fracturing of the concrete from under part of the area beneath the bearing plates of the three downstream beams, as if they had been subjected to an applied force towards the span. In addition a crack was evident on the upstream end of the pier and under the upstream approach span beam supported on the opposite face of the same pier. This suggested this beam had applied load to its anchor bolts towards its span. Temporary support

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to the three downstream beams was provided to allow two lanes of traffic to operate while repairs to the concrete were effected. It appeared that similar repairs might have been made in the past to the concrete under these bearings. The crack under the upstream approach span beam was repaired by crack injection.

The bridge showed other effects of the shaking, in that the pipes forming the intermediate rails of the handrail side protection had shifted longitudinally in a random fashion and some of the sliding joints had opened. However, this appeared to be a feature of the pipe response rather than global behaviour of the bridge, as the cold-formed top rails all showed no distortions, indicating that the bridge had not been significantly distorted. Furthermore the precast concrete duct covers and the intermediate deck joints showed no significant signs of disturbance. The only deck joint showing notable movement was that over the joint where the concrete spalling had occurred, with a 5 to 10mm opening visible.

Inspection of the 400mm octagonal reinforced concrete piles supporting the approach spans showed only minor concrete spalling at the top of one raked pile - eight approach span piers/abutments are on vertical piles and three piers are on raked piles. The eight main piers of slab form are each on two 2.4 metre diameter caissons, and no spalling was seen at the tops of the caissons or elsewhere in the piers. No signs of disturbance of the ground were seen around any of the piles carrying the approach spans.

- Kaiteratahi Bridge - State Highway 2 across the Waipaoa River, 20km northwards from Gisborne.

The bridge was built in 1986 and comprises twin structural steel composite box girders and reinforced concrete deck, with full length continuous spans of 35, 3 x 45, 35 metres. The substructure comprises single 1.8m diameter concrete piers 12 metres high on single 2.2m diameter cylinders. The superstructure is supported on elastomeric bearings at the piers and abutments, with those at the abutments resting on stainless steel plates to limit the shear force which can be transmitted to the abutments. Thus the structure is relatively flexible under seismic actions. The abutment deck joints were designed with a 150mm nominal clear gap between main members, and a steel cover plate set with a 60mm nominal allowance for movement. The bridge carries two traffic lanes.

The structure behaved as intended and showed indications of horizontal movements. The abutment deck joints and knock-off devices were not damaged or dislodged. The writer only examined the bearings at the south abutment in detail. Here the stainless steel plates under the abutment bearings showed that the bearings had "slid" (as intended in the design) in all directions by up to 35mm and the bearings showed a residual transverse shear distortion of 20mm, both in the same direction. The approach fills, which are 6 to 8 metres high, showed a settlement in the guardrails of up to 250mm. Before the visit, repairs had been completed to the north approach fill near to the bridge, where settlement of the buried approach slab during the earthquake had caused damage to the road.

P McCarten reported that at the north abutment there was evidence of transverse cyclic movement (ie in the direction along the abutment), which resulted in the two elastomeric bearings each having a 15mm residual shear distortion in opposite directions. The bottoms of the bearings were approximately 30mm closer together than their tops. This is likely to have occurred due to the lower face of the more lightly loaded bearing under transverse loading sliding on the stainless steel, while the more heavily loaded bearing did not. Cyclic variation of bearing loads would have eventuated to resist the overturning couple on the substructure caused by the horizontal forces. Successive cycles of reversing load would have resulted in the observed distortions. Evidence was not found to indicate the maximum amplitude of the deck movements. At the south abutment there was evidence that the sliding plate deck joint had closed under longitudinal cyclic motion by up to 60 mm, with marked welds indicating impact had occurred, although insufficiently to dislodge the abutment knock-off device. The bridge curves through an arc of 34 degrees over its length and this would have contributed to the apparent difference in orientation of the direction of predominant motion at the two abutments.

- Kanakanaia Bridge - Waihora Road across the Waipaoa River at Te Karaka, 25km north west of Gisborne.

This District Council bridge was built in 1976/77 and comprises continuous structural steel I girder spans of 20, 30, 35, 30, 20 metres, with two beams per span carrying a reinforced concrete deck with one traffic lane. The substructure comprises 1.5 metre diameter piers 11 metres high, supported on pilecaps and concrete piles. The girders are located at each support with fabricated steel base plates, and are held down with two 30mm holding down bolts.

Minor damage was visible at the "fixed" end abutment where the upstream beam holding down bolts were both broken. The fracture surface appears to be of a fatigue/brittle fracture mode and indicates tension was applied, possibly as a result of "stepping" action of the two-girder system. The source of the fatigue plane is of interest. Some concrete spalling had also occurred at the top of the abutment wing wall, due apparently to the wall providing restraint against transverse motions corresponding to the direction of loading which would have caused tension in the broken holding down bolts. Evidence of bolt tension was also visible at the Te Karaka abutment but the bolts were not broken.

- Frasertown Bridge - State Highway 38 across the Wairoa River, 65km south west of Gisborne.

The bridge was built in 1970 and comprises haunched continuous steel plate girders of 42.7, 57.9, 42.7 metre spans, with 15.2 and 9.1 metre approach spans. The bridge is anchored at each abutment and has an open-type expansion joint within its length, with a steel cover plate. The supporting plate at the joint showed numerous fresh scratch marks 40mm long in the longitudinal direction, suggesting significant longitudinal displacement at the joint. In contrast the Scamperdown bridge, close by but of different form and on a different type of substructure, including lead/rubber bearings at the abutments, showed no sign of displacement. Inquiry with local staff confirmed the Frasertown bridge often shows such scratch marks under service conditions. It was concluded that seismic displacements of the order initially thought to have occurred probably did not. This example shows the need for conclusions drawn from field observations to be substantiated wherever possible to avoid incorrect, and possibly significant, conclusions from being drawn.

- Three small footbridges carrying various services across the Taruheru River in Gisborne.

  The footbridges at Derby Street, Hall Street and Stanley Road all consist of light timber decking on steel beams on three, two and one x 300mm square reinforced concrete pile piers respectively. They also carry various services. The initial expectation on seeing the bridges was that they might be expected to show evidence of the shaking. However, none of the piles showed any cracking at the underside of the pier crosshead, as might have been expected. Subsequent calculation has indicated that, due to the light superstructures, the stresses likely to have been induced by the August 10 event would be quite low.

CONCLUSIONS

- Many of the bridges inspected were only of modest height and length, and with the ends of their superstructures in close contact with the approach fills. These features apparently assisted significantly by providing damping, and moderating the transverse amplification of motions, even at bridges with several intermediate piers. This has been evident from other recent moderate earthquakes, such as the Edgecumbe (1987) and Weber (1990) events. More flexible structures have behaved generally as expected in these events.

- There was insufficient overall damage/disturbance to the various bridges to be able to draw detailed conclusions on relative vulnerabilities for the purpose of prioritising for seismic assessment. However, the vulnerability of rigidly bedded holding down bolts was demonstrated by damage at two bridges. This may warrant inclusion as a feature for prioritisation.

- The damage to the one end of one span under one traffic lane at the Waipaoa bridge might be seen as a fortuitous indicator of the potential vulnerability of parts of the network. If the bridge had suffered more serious damage - as it might easily have done - access to Gisborne from the south would have been cut for a considerable time. The alternative route lies over a minor back road, or over the railway bridge. Furthermore the bridge carries a large and important water main. It appears the bridge damage arose from a small, weak and brittle area of the bridge being "found" by the earthquake motions. There must be many bridges in the network where such features exist, and where more resilience to seismic effects could probably be introduced. This example of damage, though small, is significant. It should support the case for assessment of the bridging stock in order to identify, reduce, and ideally to eliminate, the likelihood of brittle damage to details causing disruption of the network, with implications far more costly than the cost of mitigation measures. The development of assessment guidelines, currently being undertaken by Transit New Zealand, is a first step in the assessment process.

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