7. BRIDGES

This chapter documents the NZ-GEER team's observations of selected bridges in the Christchurch New Zealand area following the 22 February 2011 earthquake. Some of the bridges were previously inspected by a NZ-GEER team following the 4 September 2010 earthquake. Observations of bridge performance in the September event are documented in a previous report (NZ-GEER 2010). Whenever possible relative comparisons are made between observations made in both events.

Christchurch CBD Bridges

The Christchurch Central Business District (CBD) Bridges crossing the Avon River are shown in Figure 7-1, numbered from Bealey Avenue Bridge (1) downstream to Barbadoes Street Bridge (14). Apart from Bealey Avenue, these bridges were all within the CBD cordon put in place after the 22 February event. Overall, the bridges in the Christchurch CBD performed well, with the most common damage including minor lateral spreading, compression or slight slumping of approach material, and minor cracking in abutments. All bridges were single span and all were passable to recovery vehicles in the cordon soon after the event.

There was no damage to Montreal St. Bridge (3), Worcester St. Bridge (7), and Manchester St Bridge (11). Minor approach damage and abutment cracking was observed at the remainder of the bridges in the CBD, with the worst affected bridge being the moderately damaged Colombo St. Bridge (10). The Colombo St. Bridge is the only bridge in the CBD that is presented in any detail in this report. However, the photographs in Figure 7-2 show some examples of typical damage to some of the other CBD bridges.

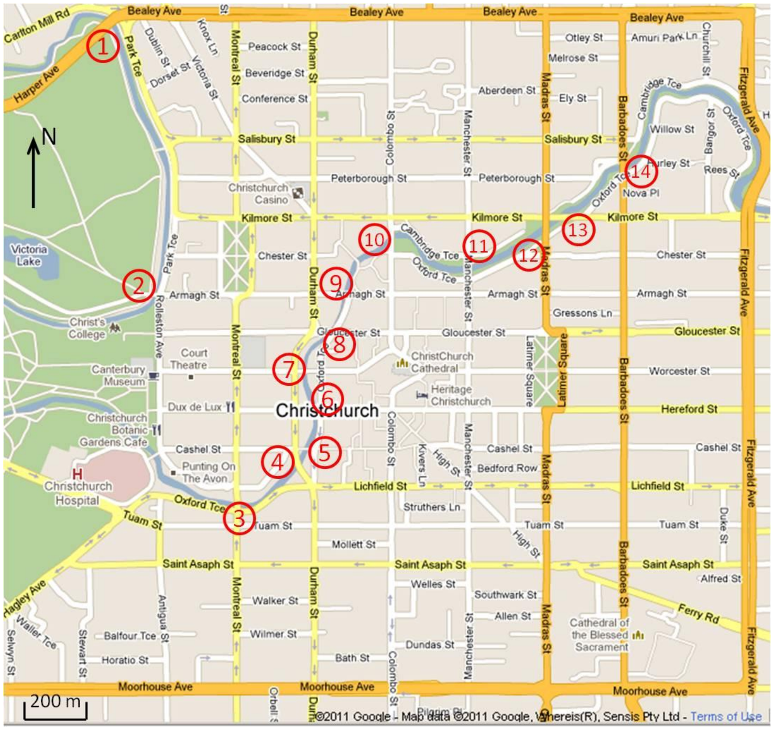

Figure 7-1. Vicinity map showing the locations of CBD bridges that were inspected by the NZ-GEER team (Google 2011).

Figure 7-2. a) Damage to the western approach of Hereford Street Bridge (6) due to lateral spreading (-43.532026° 172.633390°); b) Outward rotation of wingwalls on western approach of Gloucester Street Bridge (8) due to lateral spreading (-43.529887° 172.633986°).

Colombo Street Bridge (10)

The Colombo Street Bridge (-43.5272° 172.6366°) is a single span steel girder bridge on shallow foundations, oriented in the north-south direction. Significant volumes of ejected sand were present in the area surrounding both ends of this bridge with large lateral spread cracks to the east. Damage to the approaches on both ends of bridge was present, minor on the south approach, and moderate on the north approach (Figure 7-3a). Lateral spreading cracks were more prominent on the north side, with minor settlement of the approach material. Compression from lateral spreading of the river banks resulted in the buckling of steel bridge arches as shown in Figure 7-3b, abutment cracking, and slight back rotation. The main function of the steel arches was either architectural or for footpath support; the main structural support system for the roadway remained undamaged.

Figure 7-3. a) Moderate approach damage and settlement on northern approach of Colombo Street Bridge; b) Buckling of steel arch and handrail as a result of lateral spreading compressive forces on bridge structure. (-43.5272° 172.6366°)

Avon River Bridges (outside of the CBD)

The Avon River bridges outside the CBD are shown in Figure 7-4 and are presented below in order from the Fitzgerald Avenue Bridge (1) downstream to the South Brighton Bridge (9). The Avon is a meandering river and thus a distinction is made between the *inner bank* which refers to the inside radius of the river bend and the *outer bank* which refers to the outside radius of the river bend. Outside the CBD the Avon River widens as in nears the Avon-Heathcote Estuary. As a result, the bridges transition from single span to multiple spans.

The type of damage was fairly consistent with all the bridges that included settlement and lateral spreading of approaches and back rotation of the abutments. However, the level of damage varied significantly, with more damage observed on the inner banks of the river as compared to the outer banks. The bridges performed well in that they did not suffer structural collapse. In most cases, settlement and spreading of the approaches impacted their serviceability to some extent. However, the approaches were filled and re-graded and opened to traffic generally within 2 to 10 days after the event. Two bridges in this region suffered major damage, five had moderate damage, and two minor damage.

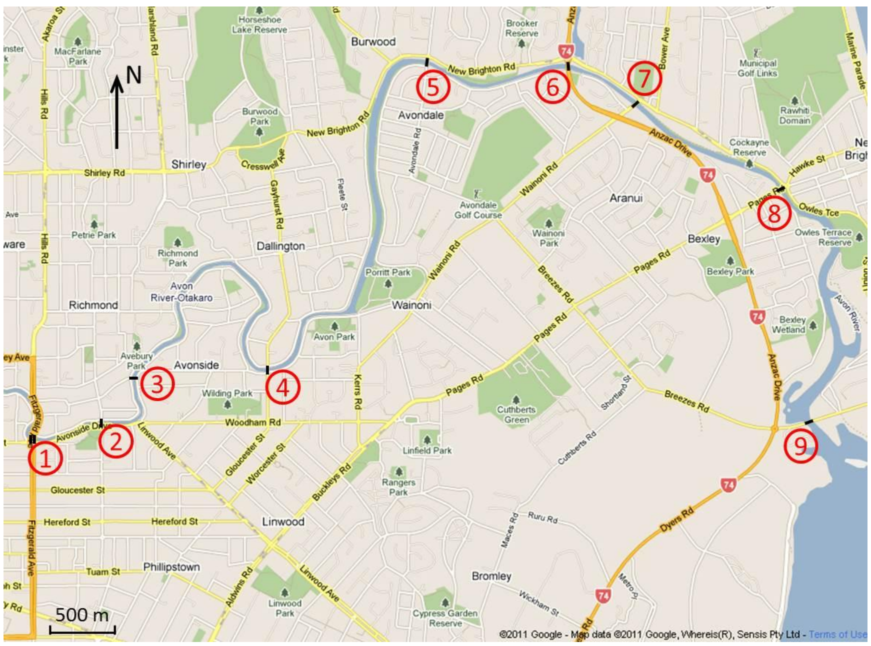

Figure 7-4. Vicinity map showing the locations of the Avon River bridges that were surveyed by the NZ-GEER team (Google 2011).

Fitzgerald Avenue Bridge (1)

Fitzgerald Avenue Bridge (-43.5263°, 172.6506°) is closest to the CBD and oriented in approximately the north-south direction. The bridge consists of two structures one supporting the southbound lane and the other supporting the northbound lane. Each bridge consists of double span precast concrete girders with a single wall pier and pile-supported concrete wall abutments. The north abutments are on the inner bank and the south abutments are on the outer bank. A satellite image of the bridge taken one day after the Christchurch earthquake is shown in Figure 7-5. This bridge was on the edge of the central city cordon, meaning it was inaccessible to the general public, and was used only by vehicles with cordon access. Approach repairs were carried out the first week of March, and as soon as the cordon was lifted in this area, traffic was able to use the bridge.

Significant lateral spreading was noted on the east side of the north abutment as shown in Figure 7-5, with cracks running parallel to the river bank and blocks of soil moving south toward the river. The northern abutment of the western bridge was very near the bend in the river having a free face both perpendicular and parallel to the bridge. Lateral spreading was noted with movement occuring both to the south and west. Settlements of approximately 0.5 m were observed on the north approach as well (Figure 7-6). Significant lateral spreading was also observed along the river banks further upstream to the north as shown in Figure 7-7.

Both north abutments showed back rotation with their bases moving toward the river as shown in Figure 7-8. This, combined with settlement of the river banks at the base of the abutments, exposed the abutment piles. One of the piles on the east side of the abutment shown in Figure 7-9 had failed in tension with reinforcement elongation of approximately 10 mm.

Minimal settlement of the approach was observed at the southern abutments. Large cracks were noted, however, in the abutment and wingwalls.

Figure 7-5. Satellite image of Fitzgerald Avenue Bridge post-earthquake (LINZ 2011). (-43.5263°, 172.6506°)

Figure 7-6. Photograph of the north approach of Fitzgerald Avenue Bridge looking toward the southwest. Note the lateral spreading cracks parallel to the river and the settlements at the abutments. (-43.5263°, 172.6506°)

Figure 7-7. Photograph of lateral spreading damage of roadway north of Fitzgerald Avenue Bridge. (-43.524156°, 172.650891°)

Figure 7-8. Photograph of back rotation of the north abutment of the eastern bridge on the eastern side. (-43.5263°, 172.6506°)

Figure 7-9. Photograph of tension failure and reinforcement elongation at north abutment of the eastern Fitzgerald Avenue Bridge. (-43.5263°, 172.6506°)

Stanmore Road Bridge (2)

Stanmore Road Bridge (-43.5252°, 172.6571°), shown in Figure 7-10, is oriented in the north-south direction. The bridge consists of double-span precast concrete girders supported on one four-column bent and concrete abutment walls. The north abutment is on the inner bank and the south abutment is on the outer bank. The bridge was opened to traffic within two days after the event. The GEER team did a rapid inspection on 26 February 2011.

Moderate lateral spreading was observed at the north approach as shown in Figure 7-11, with minor settlement on the north approach itself. Minor lateral spreading was observed near the south abutment. Cracking of wingwalls on the north approach was evident, with movement of approach material leading to the development of voids beneath the wing walls.

Figure 7-10. Satellite image of Stanmore Road Bridge post-earthquake (LINZ 2011). (-43.5252°, 172.6571°)

Figure 7-11. Photograph of the west side of the northern approach looking east. Note the lateral spreading cracks running parallel with the river. (-43.5252°, 172.6571°)

Swanns Road Bridge (3)

Swanns Road Bridge (-43.5222°, 172.6601°) shown in Figure 7-12 is oriented in the east-west direction. The bridge consists of double-span precast concrete girders supported on one wall pier and concrete abutment walls. The east abutment lies on the inner bank and the west abutment is on the outer bank. The GEER team did a rapid inspection on 26 February 2011.

Slight back rotation of both abutments was observed with minor settlement of both approaches. In general lateral spreading was more significant on the west side of the river as shown in Figure 7-13b. Cracks were also identified on the eastern approach running perpendicular to the river shown in Figure 7-13a. They appear to be shear cracks attributed to the bridge resisting lateral spreading of the approach while the adjacent soil moved toward the river. Some cracking was noted on the abutment structures.

Figure 7-12. Satellite image of Swanns Road Bridge post-earthquake (LINZ 2011). (-43.5222°, 172.6601°)

Figure 7-13. Photograph on the (a) east approach looking east and (b) west approach looking north. (-43.5222°, 172.6601°)

Gayhurst Road Bridge (4)

Gayhurst Road Bridge (-43.5216°, 172.6728°) shown in Figure 7-14 is oriented in approximately the north-south direction. The bridge consists of double-span precast concrete girders with one wall pier. The spans are supported on concrete abutments with wingwalls and pile foundations. The north abutment sits on the inner bank and the south abutment sits on the outer bank. The bridge was opened to traffic no more than two days after the event and was operational at the time of the GEER team's visit on 5 March 2011.

The north approach had been filled with coarse aggregate and re-graded at the time of the inspection as shown in Figure 7-15, with approximately a meter of settlement of the approach due to the combined effects of the Darfield and Christchurch earthquakes. The wing walls on both sides of the north abutment displaced laterally toward the river a distance of about 90 cm as shown in Figure 7-16b. The wing walls also moved laterally about 10 to 15 cm away from the abutment in the east-west direction. However, some movement was initiated in the Darfield event as shown in Figure 7-16a. As shown in Figure 7-17 the north abutment was inspected below the bridge deck and showed 5 degrees of back rotation with the bottom of the abutment moving toward the river. The bridge deck appeared to have restrained the movement of the top of the abutment.

At the south abutment there was little indication of settlement of the approach. The wing walls did not show any appreciable displacement, nor did the abutment show any measureable rotation.

Figure 7-14. Satellite image of Gayhurst Road Bridge post-earthquake (LINZ 2011). (-43.5216°, 172.6728°)

Figure 7-15. Photograph of the approach to the north abutment. Note the aggregate resurfacing and extensive pavement cracking. (-43.5216°, 172.6728°)

Figure 7-16. Photograph of the north approach of Gayhurst Road Bridge looking southwest. Note the displacement of the wingwall in the (a) Darfield event (GEER 2010) and (b) Christchurch event. (-43.5216°, 172.6728°)

Figure 7-17. Photograph of the north abutment looking east. Note the displacement of the wingwalls on either side of the abutment. (-43.5216°, 172.6728°)

Avondale Road Bridge (5)

Avondale Road Bridge (-43.5005°, 172.6878°) shown in Figure 7-18 is oriented in approximately the north-south direction. The bridge consists of a three span precast concrete girder, with 2 three-column bents and supported on abutment walls with wingwalls and pile foundations. The north abutment sits on the outer bank and the south abutment sits on the inner bank. The bridge was opened to light vehicles at most 10 days after the event and was operational when the GEER team arrived on site on 5 March 2011.

The north approach to the bridge showed little indication of ground movement or roadway damage. However, some lateral spreading was noted along the top of the riverbank adjacent to the bridge to the west. The north abutment showed back rotations of 2.5 to 3.2 degrees with the bottom of the abutment moving toward the river.

The south abutment showed 7.2 to 7.3 degrees of back rotation as shown in Figure 7-19a. Some settlement of the roadway was also noted and lateral spread cracking was observed adjacent to the approach as shown in Figure 7-19b.

Figure 7-18. Satellite image of Avondale Road Bridge post-earthquake (LINZ 2011). (-43.5005°, 172.6878°)

Figure 7-19. Photograph of the south abutment showing (a) back rotation of the abutment and (b) lateral spreading in the vicinity of the approach. (-43.5005°, 172.6878°)

ANZAC Drive Bridge (6)

Anzac Drive Bridge (-43.5009°, 172.7012°) shown in Figure 7-20 is oriented in the north-south direction and supports State Highway 74. The bridge consists of a three span precast concrete girder and two 2-column bents and supported on abutment walls with wingwalls. The north abutment sits on the outer bank and the south abutment sits on the inner bank. When the GEER team arrived on 5 March 2011 the traffic flow was heavy and it was noted that a significant portion of the vehicles using the bridge were large trucks.

The roadway and bridge abutment on the southern end of the bridge were constructed on a raised embankment that continued to south east. There were a significant number of sand boils and lateral spread cracks parallel with the river observed in the low-lying areas adjacent to the embankment (Figure 7-21), but no evidence of sand boils on the embankment itself. Lateral spreading was observed on both the sides of the south approach embankment. Cracks were generally oriented parallel with the roadway as shown in Figure 7-22a and had widths varying from about 8 to 18 cm. A short section of the south approach roadway was repaved and showed an abrupt elevation change as a result of settlement of the approach. There was additional lateral spreading of the approach embankment on the west slope that ran parallel with the river.

The south abutment shown in Figure 7-23a and Figure 7-24a back rotated about 6 degrees with the bottom of the abutment toward the river. Laterally spreading ground was observed at the base of the abutment that left a 30 to 40-cm gap between the concrete abutment and soil as shown in Figure 7-22b. This also resulted in a large horizontal gap between the edge of the walkway and the abutment, with the bridge superstructure restraining the horizontal abutment movement.

The north abutment in Figure 7-23b showed similar rotational movements but had significantly less tilting of 3.5 to 4 degrees. The lateral spreading along the base of the abutment was also less, resulting in an 18 to 24-cm gap between the abutment and the soil. The horizontal gap between the walkway and abutment was much less than that on the southern side. There appeared to be only minor disturbance to the northern approach with the exception of a lateral spread crack that was observed on the west side of the embankment running parallel with the slope.

The rotation of both abutments exposed a row of steel H-piles that support the abutment that also appeared to have rotated along with the abutment. Numerous rubber tires were also exposed that had been placed between the abutment and a walkway running along the riverbank. These tires were designed to act as a lateral spreading buffer for the walkway. Figure 7-24b shows the exposed H-piles beneath the northern abutment and some of the tire buffer material, as well as evidence of ejected material along the bottom of the photo.

Figure 7-20. Satellite image of Anzac Drive Bridge post-earthquake (LINZ 2011). (-43.5009°, 172.7012°)

Figure 7-21. Photographs of the lateral spreading and sand boils to the southeast of Anzac Drive Bridge. (-43.50144°, 172.702046°)

Figure 7-22. Photograph of the south approach and abutment. Note the (a) longitudinal cracks in the approach and (b) back rotation of the abutment and the gap between the soil and the abutment. (-43.5009°, 172.7012°)

Figure 7-23. Photographs from looking east of the movement of the a) south abutment; b) north abutment. (-43.5009°, 172.7012°)

Figure 7-24. Photographs of a) the back rotation of the south abutment; b) view beneath the northern abutment of exposed piles. (-43.5009°, 172.7012°)

Wainoni Road Bridge (7)

Wainoni Road Bridge (-43.5034°, 172.7076°) shown in Figure 7-25 is a three span concrete bridge oriented in the northeast-southwest direction. The GEER team did a rapid inspection on 26 February 2011. The river is fairly straight in this area and thus it is difficult to differentiate the outer and inner banks. Minor settlement and evidence of lateral spreading was observed. This was the only Avon River bridge that was consistently open to traffic following the event.

Figure 7-25. Satellite image of Wainoni Road Bridge post-earthquake (LINZ 2011). (-43.5034°, 172.7076°)

Pages Road Bridge (8)

Pages Road Bridge (-43.5092°, 172.7214°) shown in Figure 7-26 is oriented in the northeast-southwest direction. The bridge consists of triple-span precast concrete girders supported on two wall piers and concrete abutment walls with pile foundations. The GEER team did not inspect this bridge but it was documented that the bridge suffered damage to its approaches, requiring repair work to be undertaken.

Figure 7-26. Satellite image of Pages Road Bridge post-earthquake (LINZ 2011). (-43.5092°, 172.7214°)

South Brighton Bridge (9)

The South Brighton Bridge (-43.5253°, 172.7242°) supports Bridge Road spanning the Avon-Heathcote Estuary and it is oriented in approximately the east-west direction as shown in Figure 7-27. The concrete bridge is supported on seat type abutments with a center pier, both with pile foundations. The river is quite complex in this area and difficult to differentiate the outer and inner banks. When the GEER team arrived on site on 4 March 2011 coarse aggregate had been placed and graded on the approaches on both sides of the bridge and traffic was moving across the bridge.

Inspections of the bridge by the GEER team summarized in Figure 7-28 indicate differential movement of the abutments relative to the bridge deck. The east abutment moved about 22 cm to the north and settled about 3 to 4.5 cm. The west abutment moved 20 cm to the south and settled 8.5 to 9.5 cm. These displacements are the cumulative effect of both the Darfield and Christchurch earthquakes.

The east abutment showed back rotation of about 7 degrees as shown in Figure 7-29b. The underlying soils spread laterally thus exposing the supporting battered octagonal precast, prestressed concrete piles. The piles appeared to have rotated along with the abutment structure, with evidence of plastic hinge development in both front and rear piles. The abutment slope was covered in erosion protection consisting of riprap covered with wire chain-link fencing that had moved away from the abutment with the underlying soil. The soil movements were larger than those observed in the Darfield event (Figure 7-29a).

The west abutment in Figure 7-30b had back rotated by approximately 8 degrees following the Christchurch event. Soil beneath the abutment had settled significantly, exposing the supporting piles, which had rotated with the abutment structure. Fine sand was noted underneath the abutment at this location. Compared to the post-Darfield conditions in Figure 7-30a, there had also been a significant increase in settlement and spreading at this abutment.

A close up view of the progression in the differential displacement between the superstructure and the abutment following the Darfield and Christchurch is shown in Figure 7-31, with a much larger horizontal shift following the latest event.

Figure 7-27. Satellite image of South Brighton Bridge post-earthquake (Land Information New Zealand 2011). (-43.5253°, 172.7242°)

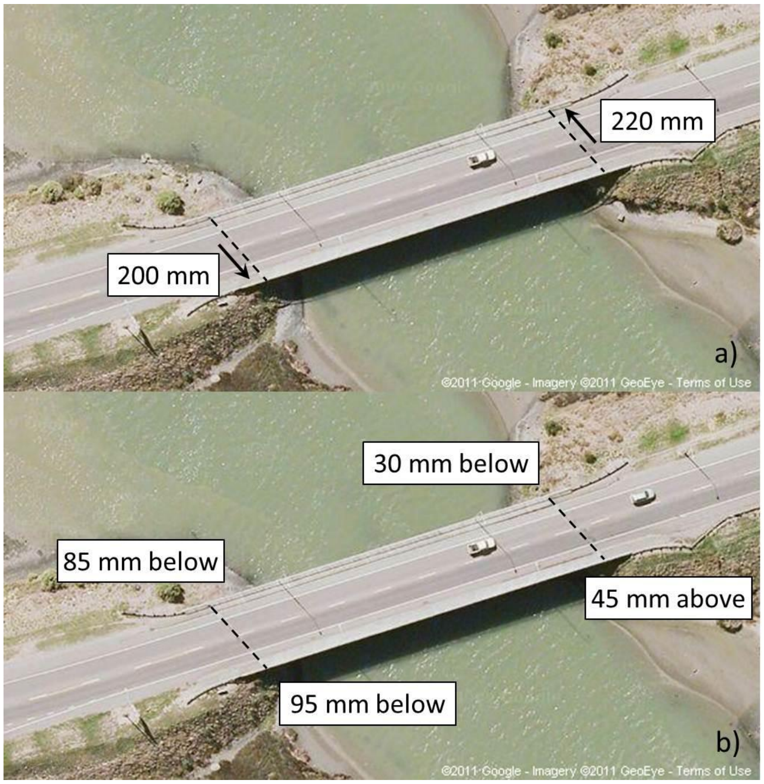

Figure 7-28. South Brighton bridge a) horizontal movement of abutments compared to bridge deck; b) vertical position of abutment compared to bridge deck. (-43.5253°, 172.7242°)

Figure 7-29. Comparison of the displacement of slope in front of east abutment after the a) Darfield event and b) Christchurch event. (-43.5253°, 172.7242°)

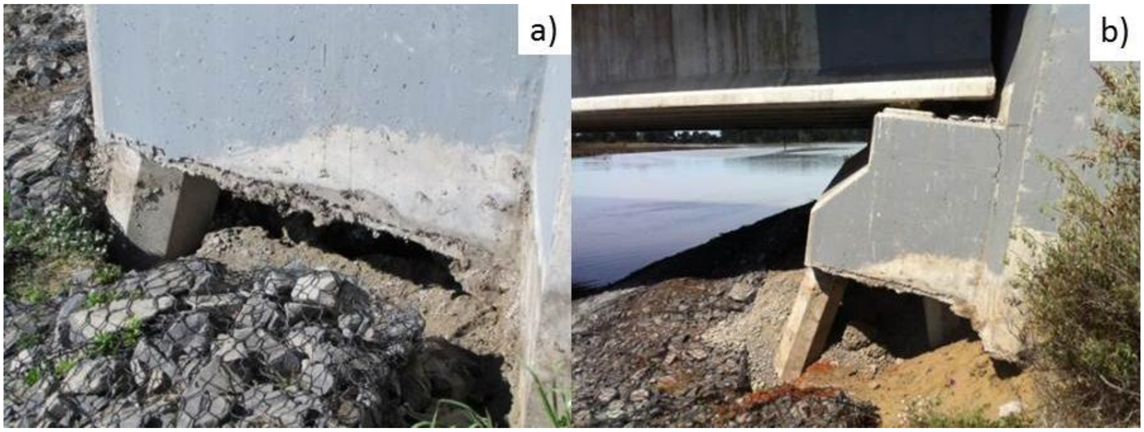

Figure 7-30. Comparison of the displacement of slope in front of western abutment following the a) Darfield event and b) Christchurch event. (-43.5253°, 172.7242°)

Figure 7-31. Comparison of the differential movement of the western abutment and superstructure after the a) Darfield event and b) Christchurch event. (-43.5253°, 172.7242°)

Heathcote River Bridges

Compared to the Avon River, bridges crossing the Heathcote suffered much less damage. Apart from the three cases detailed below, all bridges were either undamaged or suffered only minor damage. Typical damage was minor approach settlement, with little impact on the bridge abutments and superstructure. The bridges that were inspected are shown in Figure 7-32. The Heathcote River is much narrower than the Avon for most of its length. Apart from Rutherford Street Bridge (12), Tunnel Road Bridge (13) and Ferrymead Bridge (14), the bridges across this river have a span length that is smaller than those Avon River bridges outside the CBD.

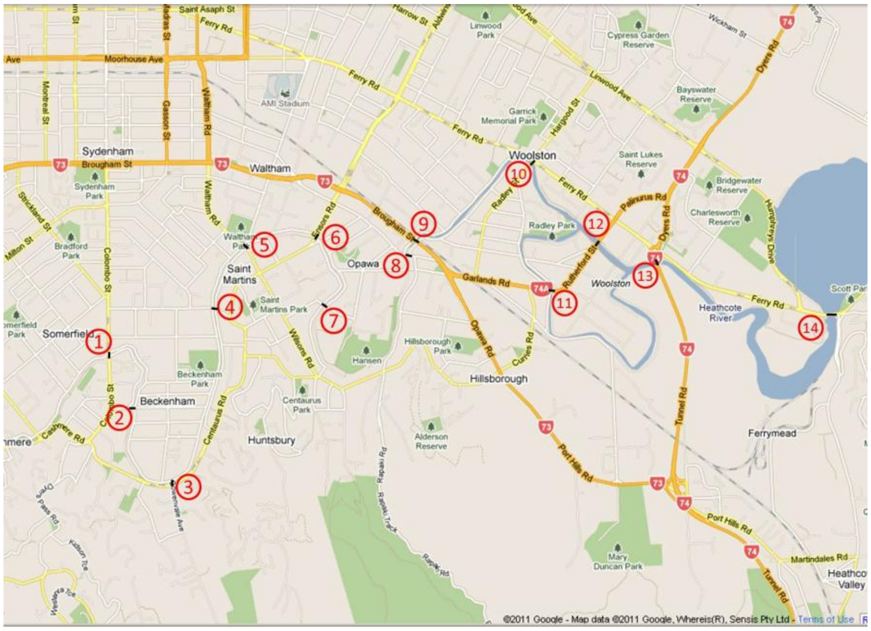

Figure 7-32. Vicinity map showing the locations of Heathcote River bridges that were surveyed by the GEER team (Google 2011).

Only Malcolm Avenue Bridge (2) (-43.565073 °, 172.639302°)was closed to traffic more than two days after the event, which suffered moderate damage to the approach and was still closed on 5 March. Ensors Road Bridge (6) (-43.552715°, 172.657477°) also suffered moderate spreading and settlement of the abutment, but was opened to traffic soon after the earthquake.

Figure 7-33. Approach damage at Malcolm Avenue Bridge (2) (Flickr 2011). (-43.565073 °, 172.639302°)

Ferrymead Bridge (14)

Ferrymead Bridge (-43.5584°, 172.7088°) supports Ferry Road spanning the Heathcote River and is oriented in approximately the east-west direction as shown in Figure 7-34. The concrete bridge is supported by wall abutments with wingwalls and two bents of column piers on pile foundations. Vehicles were travelling over the bridge when the GEER team arrived on site on 3 March 2011.

The bridge was under reconstruction/retrofitting during the teams visit. Conversations with the contractor indicated that the construction plans were to construct four large reinforced concrete girders beneath the existing structure and keep the existing bridge deck. The girders are supported on drilled shafts. At the time of the visit one of the girders at the east abutment had been completed and the girder at the west abutment was partly completed. Remedial efforts were underway to tie back the foundations supporting the westernmost pier that had experienced significant tilting. Two temporary steel bridges were erected on both sides of the bridge to allow access for construction cranes and equipment (Figure 7-34).

Conversations with the contractor indicated that the west abutment and bents are supported on floating piles, while the eastern bent is supported on end-bearing piles, and the east abutment on shallow foundations on bedrock. The existing abutments appeared to have been constructed in two sections. At the east abutment shown in Figure 7-35 the abutment section furthest from the river rotated 2.5 degrees with the bottom moving toward the river. The section closest to the river rotated 4.7 degrees. The new concrete bridge girder rotated in a different manner; it had rotated about 2.2 degrees with the top of the girder moving toward the river (i.e., front rotated). Lateral spreading was observed near the drilled shafts supporting the girder. About 33 cm of ground settlement was measured relative to the bottom surface of the new girder which was originally cast on-grade. Approximately 8 cm wide lateral cracks in the ground were also observed in the vicinity of the drilled shaft supporting the new girder, with the cracks running in both the longitudinal and transverse directions. Surveys performed by the contractor indicated minimal movement of the eastern pier, while the eastern abutment moved upwards 10 cm, possibly due to bedrock movement associated with the earthquake.

No appreciable rotation was observed at the west abutment as shown in Figure 7-36a. Surveys performed by the contractor showed that the western abutment and pier had settled 20 cm and shifted horizontally 20 cm towards the river. The soil in front of the abutment moved downward about 80 cm as shown in Figure 7-36b. Conversations with the contractor indicated that the foundations supporting the westernmost bridge pier had shifted to the east that was causing the support columns to be out of plumb. A the time of the GEER teams survey the contractor was excavating soil between the west abutment and the pier to the east so that the pier foundation could be tied back to the west abutment and possibly pulled back into place.

Figure 7-34. Satellite image of Ferrymead Bridge post-earthquake (LINZ 2011). (-43.5584°, 172.7088°)

Figure 5-35. Photograph of the east abutment a) looking north and b) looking south. Note the back rotation of the existing abutments and front rotation of the new concrete bridge girder. (-43.5584°, 172.7088°)

Figure 7-36. Photograph of the west abutment a) looking south showing no appreciable tilting; b) looking north with settlement of material in front of abutment indicated by the level of the wooden form work. (-43.5584°, 172.7088°)

Overpass Bridges

The locations of the overpass bridges that were inspected are shown in Figure 7-37 and include the Chaney's Overpass Bridge (1) and Horotane Bridge (2). These bridges are supported on large and steep embankment fills that showed evidence of slope instability. However, the bridges remained serviceable following the earthquake.

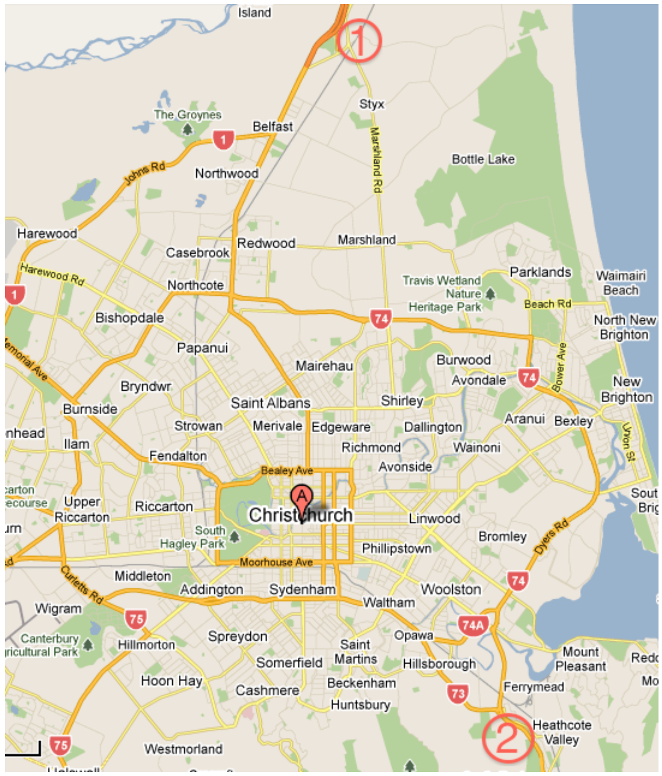

Figure 7-37. Vicinity map showing the locations of the overpass bridges that were surveyed by the GEER team (Google 2011).

Chaney's Overpass Bridge (1)

Chaney's Overpass Bridge (-43.4298°, 172.6463°) supports State Highway 1 where it crosses the Christchurch Motorway as shown in Figure 7-38. The bridge is oriented in approximately the northeast-southwest direction. The bridge is a concrete structure consisting of seat-type abutments with large approach embankments and two wall piers. The embankment slopes beneath the bridge deck had an angle of about 33 degrees relative to the horizontal (i.e. 1.5H:1V slope). Traffic was flowing over the bridge when the GEER team arrived on site on 5 March 2011.

Sand boils were noted on near the bottom of embankment fill on the northwest side of the bridge. Sand boils were also observed around the northernmost pier.

The northeast concrete abutment rotated by about 1 degree with the top moving away from the embankment. Significant movements of the embankment slope beneath the abutment were also noted as shown in Figure 7-39 which were larger than in the Darfield event. A metal drainpipe was pulled from out of the bridge deck by the embankment soil. Measurements of the pipe displacement suggest that the soil moved downward about 33 cm and also by smaller amounts laterally to the northwest. A 20-cm wide transverse crack was observed at the top of the 7.6-m long slope. The crest of the slope also moved downward at the crack location, as shown in Figure 7-40, and heave was noted at the toe of the slope. These features suggest the possibility of a slope failure extending the full height of the slope.

The southwest embankment showed less movement and cracking. A longitudinal crack was noted just outboard of the southwest support pier that had a width of 8 cm. There were also longitudinal separation cracks also observed between the concrete slope protection tiles and the soil on both sides of the slope. The separation cracks were approximately 2 to 5 cm wide. Measurements at the top of the slope near the concrete abutment showed that the soil moved downward roughly 15 cm at this location.

Figure 7-38. Satellite image of Chaney's Overpass Bridge post-earthquake (LINZ 2011). (1) (-43.4298°, 172.6463°)

Figure 7-39. Photograph of the northeast abutment slope after the (a) Darfield event and (b) Christchurch event. (-43.4298°, 172.6463°)

Figure 7-40. Photograph of the top of the slope at the northeast abutment looking southeast. Note the transverse crack. (-43.4298°, 172.6463°)

Horotane Bridge (2)

Horotane Bridge (-43.5725°, 172.6947°) supports Tunnel Road (State Highway 74) and spans over Horotane Valley Road as shown in Figure 7-41. The bridge is oriented in approximately the northwest-southeast direction. The concrete bridge is supported by seat type abutments on top of two large approach embankments and two bents of piers on shallow foundations. The embankment side slopes under the bridge have an angle of about 33 degrees relative to the horizontal (i.e. 1.5H:1V slope). Vehicles were passing over the bridge at the time of the GEER team's visit on 5 March 2011.

The northwest concrete abutment structure showed tilting of about 1 degree with the bottom displaced inward toward Horotane Valley Road. A transverse crack was noted at the top of the northwest slope near the concrete abutment. However, the crack was not continuous across the slope. A transverse crack was also noted at the bottom of the slope on the east side.

The southeast concrete abutment structure showed 3.4 degrees of rotation again with the bottom moving inward toward Horotane Valley Road. A significant transverse crack having a width of 10 cm and a depth of about 60 cm was noted at the top of the southeast slope that was continuous across the width of the bridge as shown in Figure 7-42a. A transverse scarp was also observed near the toe of the 13.4-meter long slope that also extended across the width of the bridge that can be seen between the bridge columns in Figure 7-42b. At this location the soil had moved downslope overriding the soils below the scarp. These features suggest the possibility of a slope failure. There were no sand boils noted at this site.

Figure 7-41. Satellite image of Horotane Bridge post-earthquake (LINZ 2011). (-43.5725°, 172.6947°)

Figure 7-42. a) Transverse crack running along the crest of the slope near the southeast abutment; b) toe scarp running horizontally between the columns of the southeast abutment. (-43.5725°, 172.6947°)

Railway Bridges

The locations of the railway bridges that were inspected are shown in Figure 7-43 and includes Railway Bridge No 3 (1) and Railway Bridge No 7 (2). Railway bridge No 3 suffered significant damage which caused a train derailment. However, the bridge was repaired within the first few days following the event.

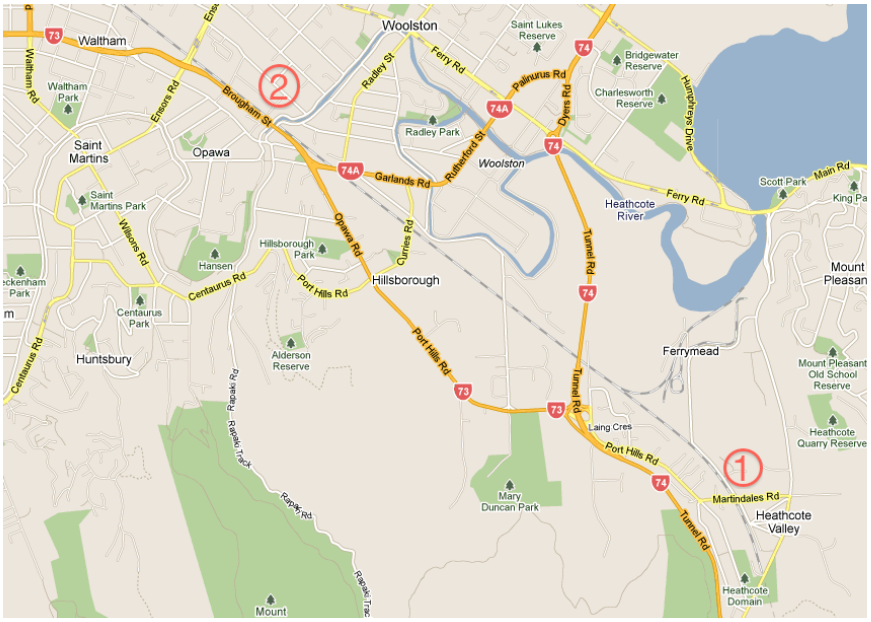

Figure 7-43. Vicinity map showing the locations of the railway bridges that were surveyed by the GEER team (Google 2011).

Railway Bridge 3 (1)

Railway Bridge 3 (-43.575963°, 172.706382°) spans Martindales road as shown in Figure 7-44. The bridge consists of a timber deck with brick masonry wing wall abutments. Conversations with Kiwirail personnel indicated that the abutments had failed in the February 2011 event but had been repaired within a few days of the earthquake (Figure 7-44). The GEER team inspected the bridge and adjacent area on 5 March 2011 after the bridge had already been repaired and the roadway re-graded.

Figure 7-44. Photograph of Railway Bridge 3 after repairs had been made. (-43.575963°, 172.706382°)

Railway Bridge 7 (2)

Railway Bridge 7 (-43.5529°, 172.6676°) shown in Figure 7-45 crosses the Ferrymead River, as well as Richardson Terrace on one side of the river and Clarendon Terrace on the other side. The bridge consists of a timber deck with concrete wing wall abutments and four bents of timber piers, as shown in Figure 7-46, and is oriented in the northwest southeast direction. The GEER team surveyed the bridge and adjacent area on 5 March 2011.

The area adjacent to the northwest abutment did not show any sand boils. The abutment appeared to have rotated slightly about 1 to 2 degrees with the top of the abutment moving inward toward the river.

Significant ejected sand was noted on the roadway pavement near the southeast abutment as shown in Figure 7-46. There was a large horizontal crack noted near the top of the southeast abutment structure and rotations of about 1 degree were noted. Again, it appeared that the top of the abutment moved toward the river.

Figure 7-45. Satellite image of Railway Bridge 7 post-earthquake (LINZ 2011). (-43.5529°, 172.6676°)

Figure 7-46. Photograph of the northeast abutment looking northwest. Note the sand deposits on the roadway and the horizontal crack at the top of the abutment. (-43.5529°, 172.6676°)

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