



## **PUKETE BRIDGE FOUR LANING – MODIFICATIONS FOR CONSTRUCTION OF PEDESTRIAN/CYCLEWAY CLIP-ON STRUCTURE**

M J FORD

Downer NZ

### **SUMMARY**

This paper outlines the physical works and challenges associated with the construction of a clip-on structure to the existing Pukete Bridge. The scope of works encompasses pre-construction investigation, reinforcing mapping, hole drilling for frame connections and erection of the frame elements.

### **INTRODUCTION**

Downer NZ was the successful bidder for the Hamilton Ring Road project, of which separable portion A includes the four-laning of Wairere Drive between Pukete Rd and River Rd.

A significant component of this section involved the addition of a further three metre wide combined footpath / cycleway to the original Pukete Bridge, thus allowing the original footpath zone to be converted to a traffic lane.

The design of the structure was undertaken following consideration of the three most viable options: –

- a replica road bridge (expensive; riverbed intrusions; RMA)
- a separate pedestrian bridge (direct eccentric loading of existing piers & piles)
- a clip-on structure (lighter than separate bridge; complex design)

MWH was the principal designer of the clip-on structure which consists of bolt-on frames located at 2.0m centres; grillage beams between frames; steel plate decking and a steel post & rail with polycarbonate panels for edge protection. The frames are designed to cantilever 5.5m from the box section outer wall due to an inability to utilise the cantilevered sections of the bridge for frame fixing.

Prior to physical work commencing, the existing structure's design was investigated and methodologies were developed to ensure the required work could be undertaken safely, and without compromising the structure's integrity.

#### Investigation Work & Bridge Condition Monitoring

The original bridge as-built drawings and construction photographic records were scrutinised in order to fully understand the structure's design and construction methodology.

During this period, a number of potential issues were identified and risk analysis was undertaken to provide a degree of comfort to all affected parties - namely Hamilton City Council, MWH, Downer, and the contract works insurer - that the work could be carried out safely and without detrimental effects to the bridge. The risk mitigation measures were incorporated into the methodology statement which covered every aspect of the modification works on the bridge.

Monitoring points were established at 10 metre intervals along each side of the bridge to provide early warnings of potential issues. At each monitoring point, measurements recorded vertical deflections and lateral movements on a weekly basis. This increased to daily recordings during critical work activities such as hanging scaffold erection, frame connection drilling, frame erection, central kerb removal, deck milling and asphalt overlay. The recordings also provided observation of any rotational (twist) movements imposed on the bridge. Temperature readings of both ambient and structural mass were also recorded. An example of these recordings can be seen below in Figure 1.

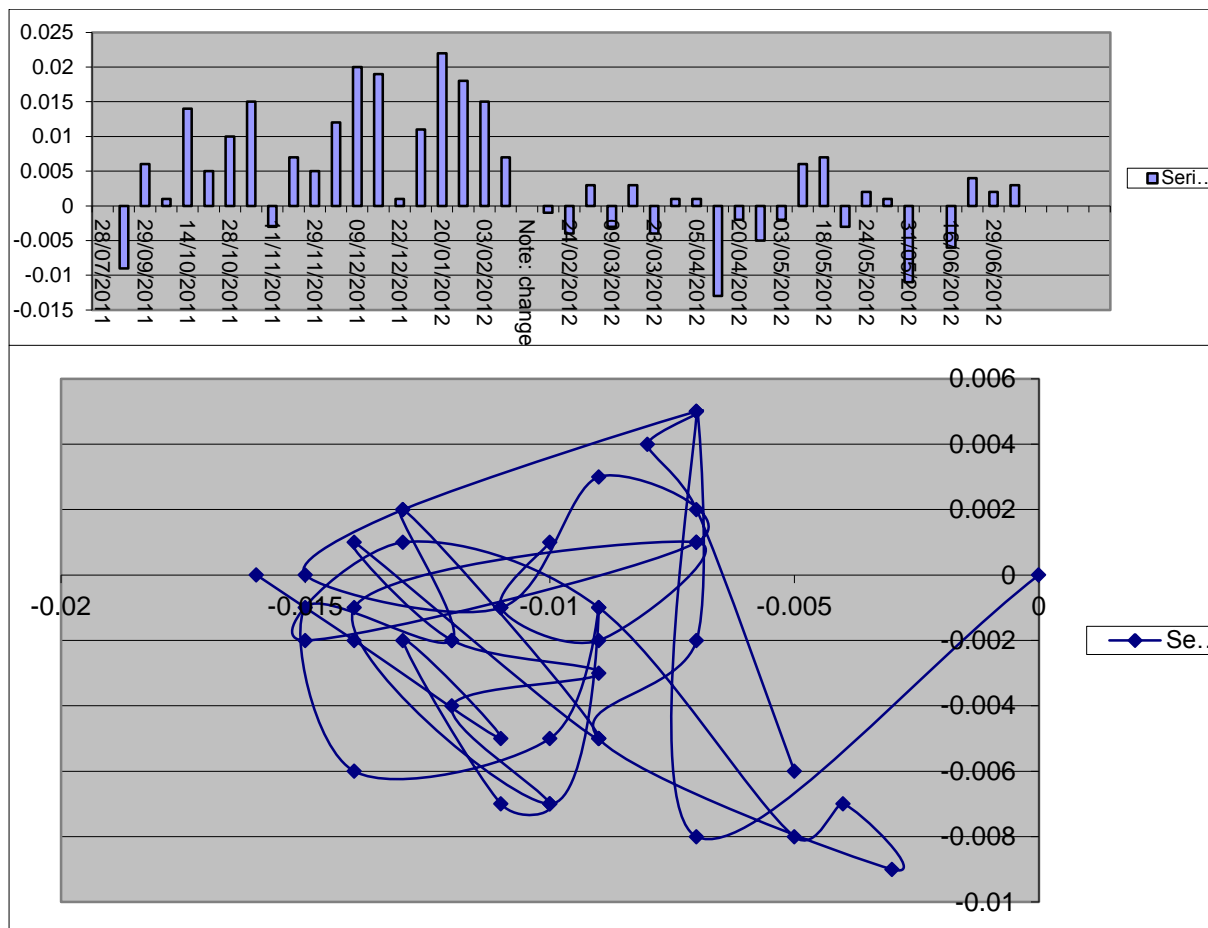


Figure 1. Vertical and horizontal monitoring records for a typical location

### Working Access

External access to the western 40m span (Delamare Rd) was gained by construction of ground mounted temporary staging. This staging spanned Delamare Rd allowing uninterrupted public use of the roadway. The eastern 40m span (River Rd) scaffolding was also ground mounted, yet was significantly more complex due to the river passing between the eastern shore and the pier-head. High level lattice-beams spanning between scaffold towers located on the shoreline and on the pier pile cap were used to overcome this challenge.



Figure 2. Main span suspended scaffold access

For the main 70m long river span, use was made of the existing 50mm diameter drainage holes plus the re-excavated construction holes located between the post-tensioned deck cables. The staging consisted of lattice beams being suspended beneath the bridge structure using Reidbar RB20 and flange nut components at 4m centres. Figures 2 and 3 illustrate this.



Figure 3. Main Span Access

Internal access to the twin box section was gained via access hatches at the eastern end under confined space working conditions.

The original footpath was converted to a working zone with the pedestrians being re-located to the main carriageway and separated from traffic by temporary barriers.

#### Pre-drilling GPR Scanning

Due to the presence of a pair longitudinal draped post-tensioned cable ducts, and a lack of reinforcing redundancy, the initial focus was to locate and identify both strand ducts and reinforcing within the outer web wall prior to drilling operations. It was critical that the tendons were not damaged in any manner; similarly damage to vertical reinforcing was avoided if at all possible.



Figure 4. GPR scanning of structure

Using ground penetrating radar (GPR) the frame locations were mapped both externally and internally. Externally, each frame location was extensively cross-scanned (horizontal and vertical) at close intervals for each connection plate location. Internal scanning consisted of full length scanning of each individual span, using location indicators at 5m intervals to confirm correction factors should they be required. This work is illustrated above in Figure 4.

The outer scan results were plotted directly on the concrete surface along with the frame centreline positions and theoretical draped cable locations. Please see Figure 5 below for an example of this.

The results of the scanning were tabulated into spreadsheet form to align the outer and inner scan information, and to relate the locations to frame centreline positions. On-site access of the spreadsheet allowed up-to-date hit/miss analysis with fine tuning between outer and inner reinforcing layers, using evidence gained during current drilling.

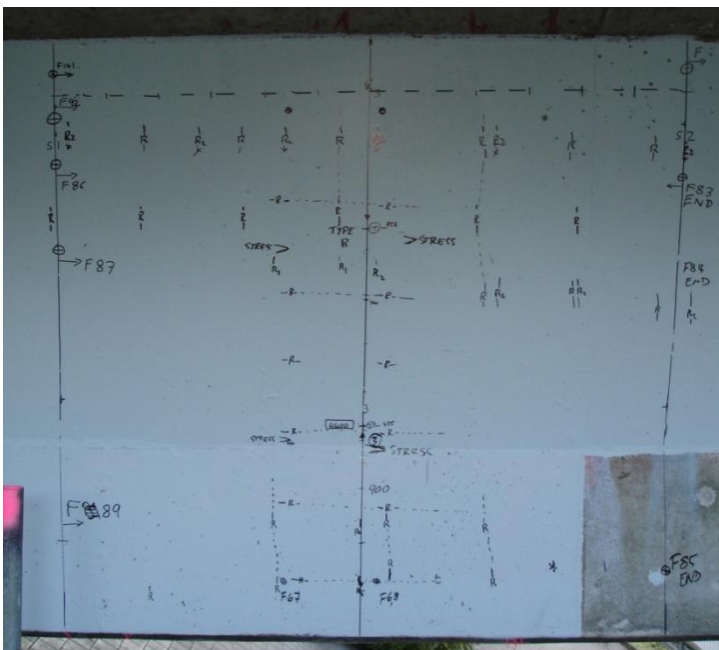


Figure 5. Typical external scan mark-up at frame position

## Hole Location Selection

The initial hole locations were nominated by MWH in keeping with the original clip-on frame design using baseplate hole configurations modified to miss the outer face rebar. However, after initial hole drilling clashed with uncharted internal rebar, it became apparent that on-site hole location selection within nominated parameters was the preferred method. Where the nominated parameters could not cater for the reinforcing variance, bespoke designs were composed for best fit solutions. As further experience was gained, we became more adept at predicting hole location successes using a combination of the spreadsheet data and general situational observations.

## Drilling Frame Connection Holes

The original specification called for percussion drilling of holes, 450 - 550mm length, to accommodate M24 bolted connections for the upper connections and also epoxy grouted M20 bolts for the lower plate connections. The designer's main concerns centred on irrecoverable damage to the primary reinforcement and the longitudinal draped post-tensioned cables. The hazards of percussion drilling the large diameter upper holes, combined with the inability to make slight offset changes with this form of drilling, resulted in alternative drilling options being investigated.

In consultation with Allied Concrete Cutters (Bill Withey) an alternative drilling methodology was developed using 30mm diameter core drilling. After significant discussions and drilling demonstrations, this form of drilling was accepted subject to strict methodology constraints.

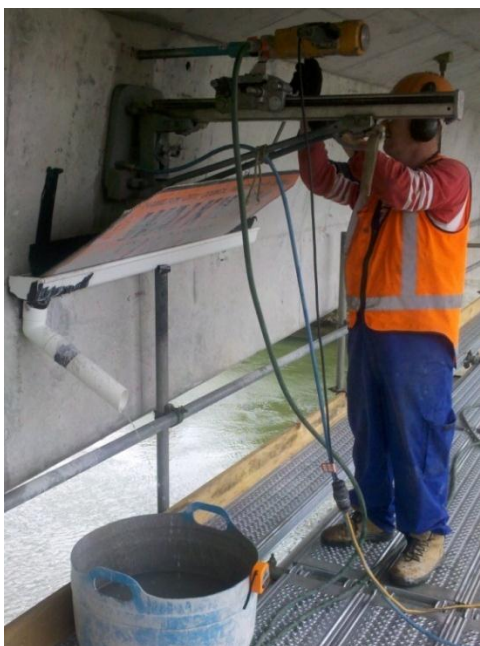


Figure 6. Core drilling of upper connection holes

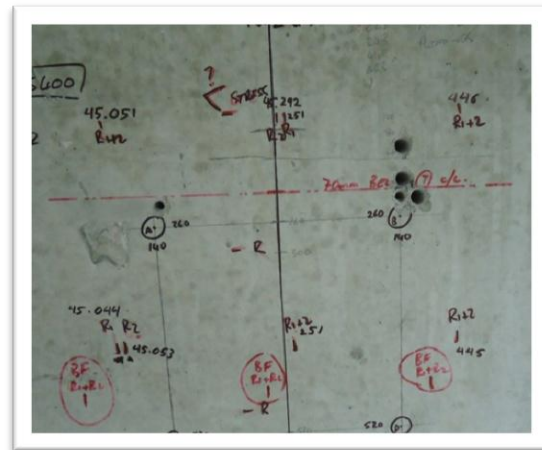
The agreed methodology consisted of the core drilling stopping when reinforcing bar was encountered. When this occurred, removal of the core and investigation followed. Ongoing progression was subject to the individual bar location, orientation, and whether the Engineer's back-analysis design had indicated bar retention was vital. Most bar encounters resulted in abandoning the attempt and re-setting to pass by the bar within offset constraints. Figure 6 above shows the core drilling of the upper connection holes being completed.



Figures 7 and 8. Borescope Images showing reinforcing bar encounters

Where offset constraints could not be overcome, permission was requested to cut (partially or fully) intersected bars. Figure 8 above is a typical example of where permission was requested to cut intersected bars. The outcome was that very few vertical bars were severed, and a number of horizontal bars encountered were cut where they had not been included in the MWH back-analysis calculations. This was due to not being indicated on the as-built drawings.

Awareness levels were at their highest when drilling in close proximity to the tendons, where zero tolerance of any form of damage existed. A methodology of percussion drilling 12mm diameter pilot holes to confirm tendon duct locations and/or clearance was employed. Yet even with clearances confirmed, the core drilling was executed in 10mm drill depth increments while in the zone of the stressing duct. Each 10mm increment involved core material removal and borescope camera inspections, until the core drill had successfully passed by the tendon duct zone. Figures 9 and 10 below show images from the borescope camera and percussion drilling pilot holes at stressing strand duct locations.



Figures 9 and 10. Pilot hole drilling at stressing strand duct locations

The use of a borescope camera allowed close inspection and identification of bars. By the end of drilling the 308 completed holes, including countless other failed attempted holes, we had become very familiar with bar diameter and orientation identification, based on location drill depth and spreadsheet information.

In a perfect world, all of the reinforcing would be located at regular intervals and in locations as per the construction plans. However, as expected, anomalies often occurred due to the non-verticality and/or non-planar orientation of stirrups which occasionally tested our faith in the scan data. Figure 11 below demonstrates this.

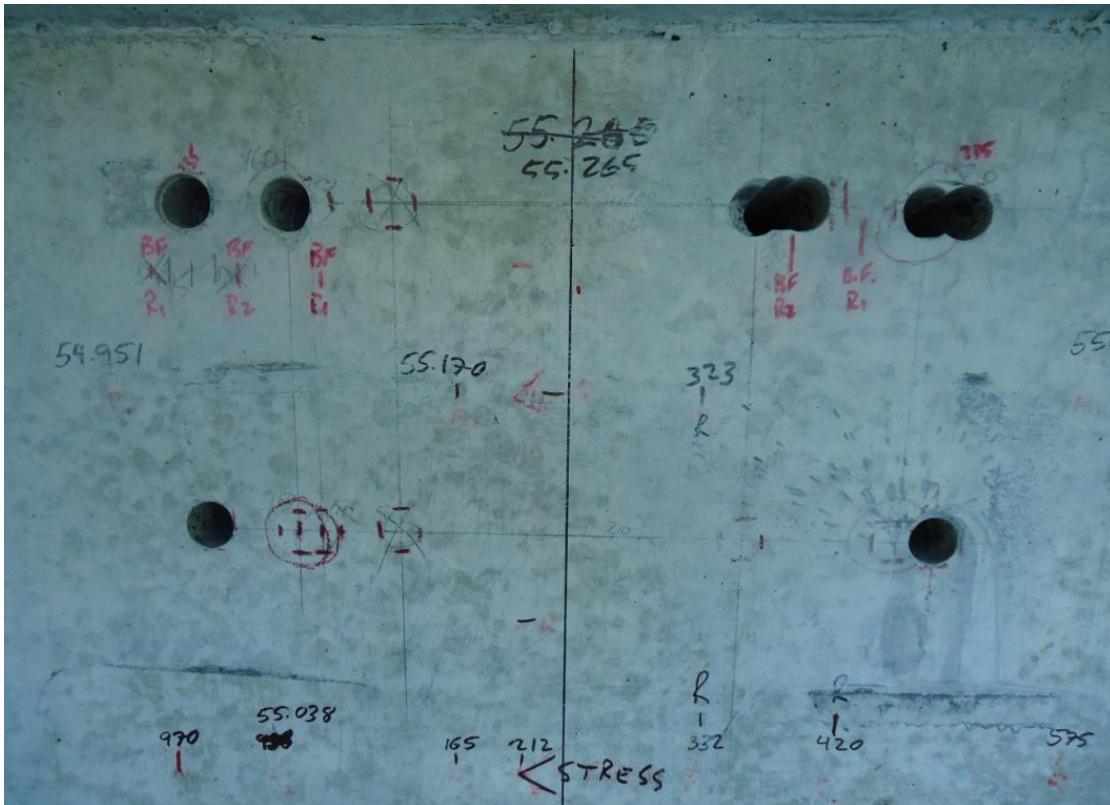


Figure 11. Four successful holes – from ten attempts

For each hole attempt, the concrete cores were recovered, logged and photographed for as-built data collection and to record any reinforcing damage.

The lower plate hole connections were percussion drilled to a depth of 170mm to accept M20 epoxy-glued anchors. Again, scan data provided the best location selection for avoidance of reinforcing bars.

### Environmental Measures

Given the combination of the close proximity to the Waikato River and wet drill methodologies, effective collection and disposal of drilling water was a major factor. Stage 1 drilling, over Delamare Rd, was used to trial and perfect the slurry containment devices prior to drilling directly above the river (stages 2 & 3). The most effective collection system comprised of a gutter system fixed and sealed to the bridge wall, and a skirt to collect the minor volumes of sprayed drill water. The drill water was collected in buckets and transferred to containers located at the bridge ends for subsequent off-site disposal.

### Frame Erection

Templates were prepared for each baseplate, two external and one internal for each frame. This was to ensure accurate fabrication of the frames. Additionally, all steel components were galvanised.

The frames were assembled into pairs, complete with grillage, to shift the combined centre of gravity outside the line of bridge deck interference. A small crane lifted the assembled pairs into position for bolting to the original bridge. Figures 12 and 13 below illustrate the frame erection being completed.



Figure 12 and 13. First frame set erection and close up of the internal upper connection

With the pairs erected, the remaining grillage between pair sets was erected, followed by handrail posts and fixing of the steel decking plate.

Final installation work involved the fixing of the poly carbonate sound barrier panels, before transferring pedestrian traffic onto the new structure.



Figure 14. Stage One frames erected



Figure 15. Aerial view of Pukete Bridge after stage one frame erection

At the time of preparing this paper, the clip-on structure construction remains in-progress.