Construction of 12 Bridges as part of the SH20 Manukau motorway extension

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1. INTRODUCTION

The SH20 Manukau Extension Project comprises approximately 4.8 kilometres of new motorway joining the South-Western Motorway (SH20) to the Southern Motorway (SH1) in Manukau.

The new motorway connection runs East-West through Manukau commencing near the Puhinui Interchange in the west and connecting to the Southern Motorway SH1 in the east.

This report details the methodology which was used by the joint venture Leighton Works (LW) in constructing 12 bridges at the project:

- BR01 – SH20 over Cavendish Drive
- BR02 – Cavendish Drive over Puhinui stream
- BR03 – SH20 over Puhinui stream
- BR05 – SH20 over North Island Main Trunk Railway
- BR05 – Plunket Avenue over SH20
- BR06 – Lambie Drive over Manukau Rail Link
- BR07 – Lambie Drive over SH20
- BR08 – Wiri Station Road over SH20
- BR09 – Barrowcliffe Place extension over SH20
- BR10 – Great South Road over SH20
- BR11 – SH20 westbound over SH1 – Flyover bridge
- BR12 – SH1 over SH20 eastbound underpass

SH20 Manukau Extension
2. GENERAL

2.1 Concrete

Concrete mix designs were approved by the designers prior to use. All concrete was supplied by Allied Concrete and delivered to site in agitator trucks. Slump testing and compressive strength cylinders were taken at the point of discharge of the concrete. No concrete was placed until a pre concrete inspection had been performed by the site engineer.

Concrete was generally placed either by chute directly from agitator trucks or by mobile concrete pump. Concrete placing and finishing was generally carried out by LW concrete crews.

Bridge deck slab pours were carried out by a specialist placing and finishing contractor. Concrete surfaces were generally cured through the application of an approved curing compound.

Concrete mixes for the bridge were as follows:

<table>
<thead>
<tr>
<th>Mix</th>
<th>Elements</th>
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<tbody>
<tr>
<td>40MPa</td>
<td>Abutments, piles, wingwalls, crosshead, diaphragms, deck slabs, barrier stitches</td>
</tr>
<tr>
<td>40MPa 10mm Aggregate</td>
<td>Expansion Joints</td>
</tr>
<tr>
<td>30MPa</td>
<td>Precast barriers, in-situ barriers, barrier end posts, kerbs, footpath, settlement slabs, bored piles.</td>
</tr>
<tr>
<td>50MPa</td>
<td>Precast super tee beams, precast piles</td>
</tr>
</tbody>
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Concrete pour at BR03, SH20 over Puhinui stream
2.2 Reinforcement

Reinforcing steel was scheduled, supplied and fixed by the subcontractor Steel and Tube Reinforcing. Reinforcement was generally supported on concrete chairs. Trimming bars were fixed at the corners of all penetrations. Quality assurance checks were undertaken by the project/site engineer during and following the placement of reinforcing.

2.3 Construction joints

Following concreting, Rugasol was applied to the surface of the construction joints to enable green cutting with high pressure water jet the next day. Where fresh concrete couldn’t be green cut, mechanically operated scabbling tools were used to remove laitance from the joints.

2.4 Concrete repairs

Repairs to concrete were carried out using Sika Monotop concrete reinstatement mortar in accordance with the manufacturer’s recommendations. Sika Monotop Primer was used to bond the repair mortar to the concrete substrate. In situations where repairs were carried out to a surface requiring an F5 finish, a cement fairing coat was applied in a thin layer (less than 3mm) with care being taken to match the colour and appearance of the cured concrete.

BR02, Abutment Reinforcement
3. FOUNDATIONS

Foundations consisted of different types of piling and pad foundations as determined by the geotechnical engineers from Golder Associates. Pad foundations were used only for the piers 1 – 4 at BR04, SH20 over the Railway, due to shallow basalt levels.

On 3 out of 12 bridges Leighton Works installed 350 mm x 350 mm precast concrete piles, BR01 over Cavendish for the piers, BR08 at Wiri Station Road for the abutments and the flyover BR11 for the southern abutment.

Driven piles were installed with different dimensions at BR01 st Cavendish Drive, BR02 and BR04 over the railway. The steel H piles used were 310 UC 137 and 310 UC 96.8.

Bored pile foundations varied from 750 mm diameter for a local road bridge at Barrowcliffe Place to 2200 mm diameter for the flyover bridge over SH1.

All piles are socketed into the underlaying sandstone or basalt.

3.1 Foundation of BR04 SH20 over North Island Main Railway

Foundations consisted of pad footings at piers 1, 2, 3, 4, and driven steel H-piles (310 UC 137) at pier 0 and the west and east abutments. Piling works were carried out by Hauraki Piling.

Piles were grouped together with pile caps at the appropriate piers and via the abutment foundation at the bridge abutment. Pile caps were linked together at each pier with link beams.

Under the pad footings at piers 2, 3, and 4, the ground was excavated to the top of the basalt layer and then backfilled with compacted GAP65 to the underside of the pier cap.

Under the pad footing at pier 1, the ground was excavated to the top of the basalt which was generally immediately below the intended soffit level of the pier cap. The reinforced concrete pier cap was deepened where necessary to key into the basalt layer. Where there were cavities and fissures in the basalt, grout was injected and cored to prove integrity.

At pier 0, the original intent was to use a pad footing as for the other piers. However, the proximity of the NIMTR lines meant that it was not feasible to excavate the necessary width of footing under live rail conditions. Instead, a steel H-pile design, founding on the basalt layer, was adopted. This proved successful, except for one instance where 2 piles did not found on satisfactory basalt. A further 2 piles were driven in an adjacent position and the pier cap extended to include these. A design check was carried out by the Designers to prove both geotechnical and structural integrity.
3.2  Foundation of BR05 Plunket Ave over SH20

Foundations consist of 900mm diameter bored piles for 8 piles at the 2 abutments and for 60 piles for the 6 piers. All piles are socketed into the underlying sandstone with UCS >2Mpa as determined by a geotechnical engineer from Golder Associates.

The bases of piles were cleaned of loose or disturbed material and a temporary lining inserted. Where deemed necessary polymer was used during drilling to maintain the sides of the pile until concreted.

All piles were poured as each hole was charged with water to maintain the hole stability during concreting. Piles were cast to a level to allow 50mm of projection into the abutments and pile caps.

![Finished Piles at BR05 with 50 mm embedment into pile cap](image)
4. **SUBSTRUCTURE**

4.1 **Abutment crosshead**

After completion of the foundation a blinding slab no less than 50mm thick was cast at each abutment and pier location, with the top of the blinding slab matching the soffit levels of the abutment. 15MPa GP concrete was used for construction of the blinding slabs. Reinforcing steel was fixed after the blinding slab had set. Steel reinforcement was checked and signed off prior to installing formwork to the abutment. The Engineer was invited to inspect the reinforcement prior to installing formwork.

Formwork comprised of form ply shutters with RMD soldiers and LVL whalers. Formwork was pre-assembled in sections, delivered to the work location by truck and man-handled into position.

The abutments were usually cast in two stages, the first being the crosshead beam and the second the wing walls, keeper walls and ballast wall. Bearing pedestals were cast separately using Sika 212 grout.

All formwork was installed to the satisfaction of the site foreman and site engineering staff and was inspected prior to each pour. Prior to pouring abutment concrete a final inspection of reinforcement was carried out including a check on pour inserts and cover to reinforcement. A similar procedure has been implemented for all secondary pours.

Reinforced earth straps extend from fixings cast into the back of the abutment. The straps were installed as the abutment fill was brought up to the level of the settlement slab soffit. When the fill reached this level, the settlement slabs were cast on top of a 50mm blinding layer or compacted fill with a polyethylene liner.

The settlement slab consists of a 250mm thick RC slab on a 1:40 slope away from the ballast wall. The slab was separated from the ballast wall and abutment crosshead by strips of PE30 compressible foam. YD20 starter bars were cast into the abutment for connection with the settlement slab. Bars were Denso tape wrapped at the interface between the slab and abutment to allow movements.

4.2 **Pier crosshead**

**Pier crosshead at BR04 SH20 over North Island Main Railway**

Prior to forming piers, the fill around each pile cap was levelled to the top of the pile cap. Pier columns generally consisted of 1200mm diameter (1350mm diameter for larger spans at piers 3 and 4).

RC columns interconnected with crosshead beams. Columns were formed using a steel shutter erected following fixing of the reinforcing steel.

The top of the columns were cast level with a maximum of 50mm projection into the crosshead beam. Columns were poured using a mobile boom pump.

Following construction of the columns, the Rapid Metal Development (RMD) false work was erected using the pile cap / pad footing as a foundation.

The false work consisted of Rapidshore standards and ledgers, superslim soldiers and LVL bearers.

Shoring was erected up to the level of the U-heads in accordance with the approved design. A scaffold stair access, handrails and scaffold plank walkway was erected and tagged by a qualified scaffolder.

After signoff the crosshead soffit was decked out with LVL bearers and formply before reinforcing was fixed.

After installation of shutters LW engineers completed a final inspection of reinforcement and false work and invited the Engineer for final inspection prior to ordering concrete. Concrete was poured using a mobile concrete pump.
The rebates for the pedestals were formed using Rugasol coated plywood formers and then green cutting the surface following casting of the crosshead. Bearing pedestals were cast using a Sika 212 pourable, cementitious grout.

Piers 3 & 4 have post tensioned tendons through each crosshead. Post tensioning ducts were installed by Leighton-Works and strand installation, stressing and grouting works carried out by VSL as the specialist subcontractor.

The design sequence called for the crossheads at pier 3 and 4 to be stressed prior to positioning of the beams. During post-tensioning of the pier heads, minor tension cracking was noticed in the top of the crosshead and in the inside face at the top of the outer columns. This cracking closed (became invisible) immediately under dead load once the superstructure beams were placed.

4.3 Retaining wall at the eastern abutment of BR04

The east abutment comprises an earth retaining wall structure consisting of precast panels sized 2 m by 2 m and 200 mm thickness. The concrete panels were placed, held in place by earth straps extending into compacted granular fill material placed to specified earthworks requirements.

5. SUPERSTRUCTURE

5.1 General

The superstructure generally consists of simply supported 1200 mm deep Super Tee beams, placed on elastomeric bearings on the abutments and pier crosshead beams. The deck was made continuous between movement joints with in situ reinforced concrete. The movement joints were located at each abutment. Insitu anti-sliding blocks, diaphragms and deck slabs were then constructed to complete the superstructure. Two out of twelve bridges were built differently by using double hollowcore beams for BR06, Lambie Dr over Manukau Rail Link and by constructing an in situ concrete slab to BR12.
5.2 BR04, bridge beam placement methodology

The bridge beams were precast units manufactured offsite at the Leighton-Works pre-cast yard in Takanini. The tapered bearing plates were fixed to the beam soffit on site. No beam was placed in its permanent position until the supporting abutments and pier had attained their full specified 28 day concrete compressive strengths.

The beams were erected from the furthest beam position working back towards the crane. Once the first beam had been placed in position, and prior to releasing from the hook, the beam was propped temporarily to prevent rolling. Each successive beam placed, prior to releasing from the hook, was connected to the previous beam using temporary supports anchored into the beam flanges.

5.3 Diaphragms

Anti sliding blocks were cast on top of the crosshead beams in four locations following placement of the super tee beams and before casting the diaphragms. Diaphragms were cast to a level matching the top of the super tees and extend down to the top of the super tee end block. At the location of the anti sliding blocks a downstand in the diaphragms was extended the full depth of the super tees, encasing the anti sliding blocks. Reinforcement couplers were cast into the end blocks for connection into the downstand reinforcing. A 20mm thick layer of compressible EVA120 was installed to separate the diaphragm from the anti sliding block on all sides.
5.4 Bridge deck construction

The bridge deck consists of an RC slab of a minimum 200mm thickness. The thickness of the deck slab varies along the length of the bridge due to the hog in the bridge beams. The bridge deck was cast in separate sections. Each span was cast separately, leaving a 5m long block out over the piers.

The block out was poured after a settlement period determined by the geotechnical engineer. Settlement of the foundations was monitored and this information relayed to the geotechnical engineer, and the block outs poured only after the geotechnical engineer was satisfied that significant consolidation had ceased.

The soffit of the bridge deck was formed by the flanges of the super tee beams with soffit boxing of 25mm thick rough sawn timber spanning the voids in the beams. The narrow gaps between the adjacent beam flanges were covered by multi seal tape. Height pins were used to control the finished levels during casting of the slab with the pins being removed once the concrete had been screeded. Concrete was placed using a mobile concrete pump and compaction was achieved by the use of poker vibrators.

5.5 BR12, SH20 southbound underpass deck construction methodology

The superstructure consists of a 700mm thick in-situ reinforced concrete solid slab with 1200mm deep haunches and 1700mm deep capping beams. Additional upstands are provided running longitudinally along each edge of the deck with additional strut beams provided at the western portal.

Following installation of the piles, an accurately controlled excavation was carried out and a layer of blinding concrete poured to form the underside of the deck. The blinding concrete was mechanically floated to provide smooth surface finish. Crack inducers were placed in the concrete and two layers of a bond breaker were applied to ensure the blinding concrete broke away easily during excavation beneath the deck.
The deck was concreted in a single pour for each of the three stages of construction. Due the volume of concrete required, the main deck pours occurred at night and standby equipment was available to ensure the rate of concrete supply and placement could be maintained. The upstands for the portal beams and the capping beams at the approach walls were concreted separately to the main deck.

5.6 Services

All services except street lighting were supported beneath the structure on brackets with cast in fixings to the bridge deck via voids in the flanges of the super tee beams. Penetrations were formed into the abutment ballast walls to carry the services through the abutments at either end of the bridge. Street lighting services were run through the deck into conduits located in the precast barriers. All service hangers were installed prior to casting of the bridge deck. Where service ducts were provided for future use they were generally run a further 10m past each end of the bridge or until they were clear of the road carriageway. Where services were relocated they were run a sufficient distance to join existing ducts. Street light ducting was provided and installed within the barriers on either side of the bridge. This consists of 1 No. Ø100mm duct each side. A chamber was cast into the barrier to act as a pull pit for cabling to each light pole.

5.7 Barriers

Precast concrete TL5 with Texas HT rail traffic barriers were provided to each side of the bridge deck. Ferrules precast into the bottom of the barriers have threaded bars installed for support and levelling. Barriers were held in place using push pull props fastened to the top of the barriers. Following placement of the barriers an infill stitch was cast to form the connection between the precast and insitu bridge elements. Stirrups from the deck and from the barriers overlap within the stitch and 5 No. YD16 bars were threaded through to act as the longitudinal reinforcement.

A galvanised bridge rail was fixed to the top of the precast concrete barriers by cast-in bolts. Dry-pack mortar was used to fill the void beneath the post base plates following final alignment of the railing.
5.8 Expansion joints

Strip seal expansion joints were located at the abutments at either end of the bridge and extended across the whole width. Buffer plates were cast in with the expansion joint at each end and at 6m centers. Expansion joints were constructed following casting of the bridge deck slab in accordance with the manufacturer’s recommendations. One side of the expansion joint was cast followed by the other side with polystyrene forming the void between the two.

5.9 Surface finish

In general all formed surfaces on bridges which are visible to the public have an F5 surface finish. The specified surface finish was achieved through the use of good quality formwork with attention to joints in the form. Sika Formol concrete form release agent was applied to formwork shutters prior to erection. Following the removal of formwork, exposed concrete was inspected for defects and the surface rubbed down as required. Any defects were noted and repaired. The top surface of the bridge deck had a U5 (broom) surface finish.

6. Conclusion

Auckland’s much needed Western Ring Route is one step closer following the opening of the SH20 Manukau Extension in 2010. The Leighton Works joint venture successfully delivered 4.8 km of new motorway with 12 bridges, over 220,000 square metres of road pavement, 41 retaining walls, slip form, precast and in situ barriers and 16.8 km of drainage.