Construction Management under Tight Constraints: SH1 Ellerslie Widening

Practice Paper

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ABSTRACT

This paper will detail the:

- Process for delivering the Ellerslie Motorway Widening project under tight-constraints,
- Design and construction challenges of the project; and
- Innovations during construction to accelerate the project.

SH1 Northbound at Ellerslie, between Panmure and Greenlane in Auckland, is a major bottleneck due to a short merge from Panmure Roundabout onto SH1. This causes congestion and delays in the morning and afternoon peak. The project aims to relieve this congestion, improve traffic safety, and create traffic efficiency and trip reliability. The project was divided into three stages, enabling works by relocating the train tracks and upgrading the Ellerslie train station (completed), relocation of the Main Highway Bridge Pier(completed) and the motorway widening to create four lanes (under construction).

The major constraints to this project are:

- The available space to construct the additional lane,

- Requirements to work within 24 kV electrified rail corridor,
- Variable ground condition in the area,
- Operational requirements (both motorway and rail corridor) and
- The stringent design criteria for the TL6 Barriers.

To achieve the outcome, we engaged with the stakeholders from the start of the design, established project partners and worked closely with the partners to come up with innovative solutions during the construction phase of the project. To date, we have used this innovation to reduce the construction costs which also lead to early completion of the project.

Introduction

The SH1 Southern Motorway is a key strategic corridor for NZ Transport Agency providing the key connection north and south of Auckland. It also provides the access to the important ports and employment areas within Auckland. Traffic volumes have continued to increase along the SH1 Southern Motorway and whilst ramp metering implemented in 2008 has provided some relief, the motorway has become increasingly congested with the Ellerslie Panmure northbound on-ramp becoming a major bottleneck.

The project is located on the northbound lane of SH1 in Auckland, between the Ellerslie Panmure Interchange and the Greenlane Interchange, adjacent to the Ellerslie train station refer Figure 1.

Figure 1: Project Location

The Government Policy Statement in Land Transport Funding, May 2009 (GPS) highlights the government's main priority as being to increase economic growth and productivity. This project effectively contributes to that priority by:

- Improving journey time reliability through additional capacity;
- Easing congestion through the provisional of additional capacity and on-ramp efficiency;
- Making better use of the transport corridor by making more effective use of the rail corridor and increasing traffic capacity;
- Improved access between Auckland and Hamilton; the ports and employment areas.

- Providing opportunities to manage lanes for better maintenance and operational performance; and,
- Reducing upstream congestion caused by knock on effects at the Ellerslie Interchange.

The main objectives of this project are to improve safety and increase the capacity of this section of the motorway which is the main cause of the congestion upstream of the Ellerslie Panmure interchange.

The delivery of the project is divided into three stages to allow for the widening. These are:

- Stage 1 – Re-alignment of the train tracks and station upgrade prior to electrification (Competed in 2012)
- Stage 2 – Relocation of Main Highway Bridge Pier to provide the required space for the additional lane (Completed in 2014)
- Stage 3 – Actual Motorway Widening and provision of the fourth lane (Due to complete March 2016)

This paper focuses on the construction of Stage 3 - Motorway Widening.

Approach

The delivery of all stages of the project was intended to be completed prior to the electrification of the rail lines. During the second stage of the project and the design of the third project, it was announced that the EMU (Electric Motor Trains) testing and commissioning would be brought forward. This meant that construction of the second stage and the third stage would have to be completed while the electric wires are live and the trains were in operation. This was the main challenge and risk of the project as it is the first section of the rail network in Auckland that will operate electric trains that also required new guidelines and processes for operation.

The two main stakeholders in the project, which are KiwiRail and the Auckland Motorway Alliance (AMA), were involved from the start of the design phase through to the construction phase of the project. During the design phase, design inputs allowed the design team to understand the challenges and provide a constructible design. KiwiRail was also involved during the tender phase of the project to assess the methodology of the contractor and any alternative design that the contractor had proposed.

As part of the contract, a Project Management Board (PMB) was set up at a governance level. Senior managers from each organisation including the stakeholders NZ Transport Agency and KiwiRail was selected to oversee the project team. This created a team approach in delivering the project which made project decisions that was best for project and also created a no blame culture

Major Challenges / Constraints

There were five major challenges designing and constructing the Ellerslie widening project. These are listed as:

- Available Physical Space and access between railway and motorway
- Requirement to work within 24kV electrified rail corridor
- Stringent Design Criteria
- Variable ground condition in the area
- Operational requirements (both motorway and rail corridor)

Each challenge is difficult to overcome in any project. The combination of the five challenges requires the project team to come up innovative solution and extensive planning to construct the project within the contracted 16 months.

Available Physical Space

After the narrowing of the train platform and the relocation of the train tracks, the width between the centreline of the tracks and the existing concrete barrier was approximately 5 metres at the narrowest point. After the installation of the proposed new concrete barrier this distance would be 2.75 metres along the Ellerslie train station section.

The original methodology was to use the existing concrete barrier as protection from the motorway traffic while the new concrete barrier is constructed. This means that there is only 1.25 metres of working space (after 1m safety zone is deducted) between the rail and the motorway. With the narrow working space the contractor would have to depend on KiwiRail's Blocks of Line (BoL) to do most of the works using heavy machinery from the rail corridor. The rest of the time the contractor would have to use small hand tools which affect production. The programme then placed critical items like piling, excavating and rock breaking into the BoLs and the forming and bracing of the formwork during the rest of the period. The productivity of the project would spike during BoL and there would be periods of time where there will be no work on site due to the long period time between the BoLs.

After the Easter weekend (2015) BoL the project team came up with an innovation that would temporarily narrow the three motorway lanes to 3.25 metres each and use a W-Section steel guard rail as the protection between the motorway and the work area. This project is the first project to us TL4 Nu-Guard barrier system as a temporary barrier on SH1. The Nu-Guard system was also selected to maximise the working area for the contractor as it does not require any block-out between the steel post and the guardrail. This increases the working space to just more than 5.5 metres (after the 1 metre deflection safety zone is deducted) at the narrowest point. The new methodology allowed the contractor to continuously work throughout the duration of the project as they have enough space to work, store materials and operate plant, albeit still within an incredibly narrow corridor. The Figure 2 below shows the complete design next to the Ellerslie train station, being the narrowest location. This then allowed works to continue during the daytime, accessing from across the rail tracks and night time accessing from the motorway.

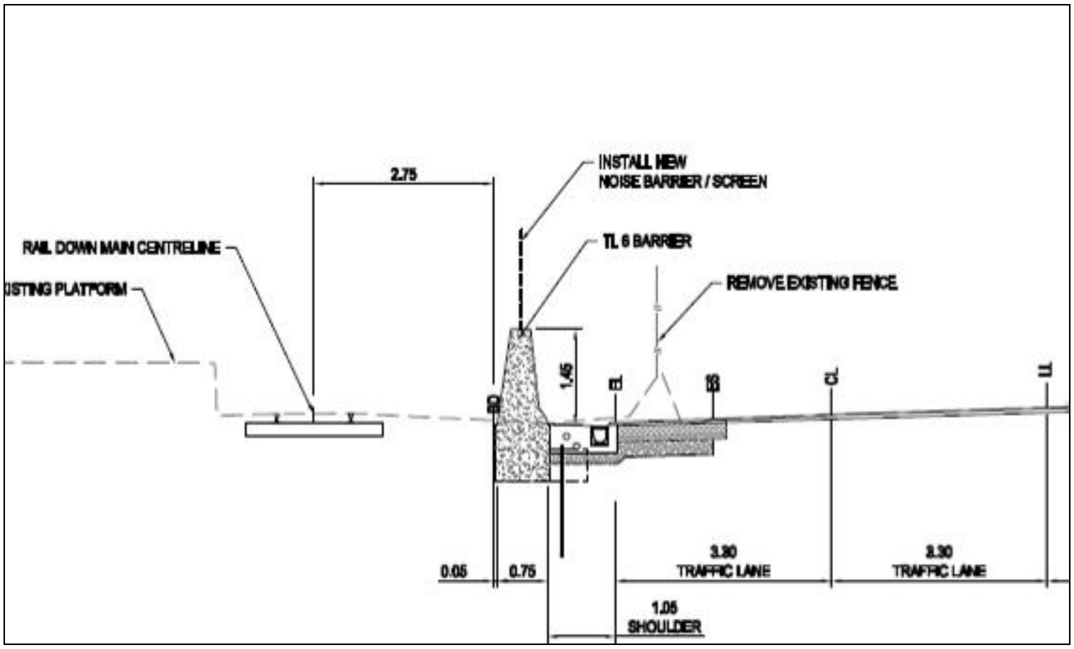

Figure 2: Cross section of the narrowest point of the project

Requirement to work within 24kV electrified rail corridor

Auckland was the first part of New Zealand to have a 24 kV Alternating Current (AC) to be implemented on the rail lines. Working close to and under AC lines requires a different methodology and training when compared to the Direct Current (DC) used in Wellington. This would make the project the first to have plant and machinery working close to the live wires for a long period of time.

There is a Minimum Approach Distance (MAD), refer Figure 3, for all plant and machinery which is 4.0 metres from any traction structure. This combined with the limited physical working space meant that machinery can only work during Isolations (when the power to lines is turned off). The Isolations are available between Sundays to Thursday, each night between midnight and 4 am. This allowed the contractor to do all the major works during the night shift and do all the preparation work during the day shift.

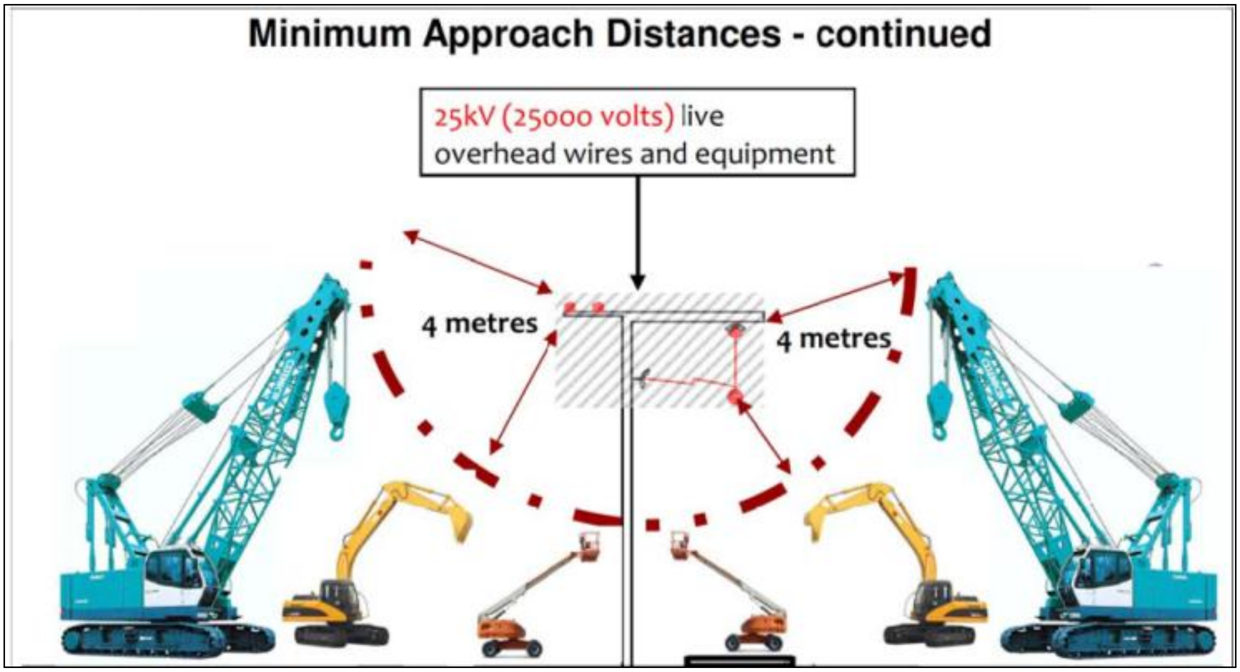

Figure 3: KiwiRail 4 Metre Minimum Approach Distance (MAD)

Stringent Design Criteria

During the design phase of the project, KiwiRail requested that the deflection of the barrier should be less than 5 mm upon impact (impact deflection) and zero deflection after impact on a TL6 barrier load (36 T truck). This required the design to have a pile foundation (if the foundation beam is on clay) or mini piles (if the foundation beam is on basalt). This allowed load transfer to the abundant mass of basalt rock that this section of the motorway is founded on. There was also surety that the rail tracks or any of the asset holding the 24 kV cables would not be damaged in the event of an accident on the motorway.

During the construction of the piles and mini piles there were different issues encountered with the sub-strata of basalt that slowed production. Since KiwiRail were involved in the project throughout the design and construction period, the project team requested that KiwiRail review the criteria and consider construction challenges in installing the pile foundation. KiwiRail determined that the best solution is that there should be zero deflection at the rail rather than at the toe of the barrier, which at the narrowest point is 2.75 metres from the centre of the track.

Based on this new design criterion, the project team designed an alternative barrier system which has the foundation beam wider, with no piles or mini-piles, which would absorb the impact load. With the alternative design, the need for BoLs significantly reduced as there was no large plant required and all works could be completed with standard plant during night shift. Figure 4 shows the new foundation beam. The new design has an 8 mm calculated deflection at the toe, which reduces to zero at the rail after impact.

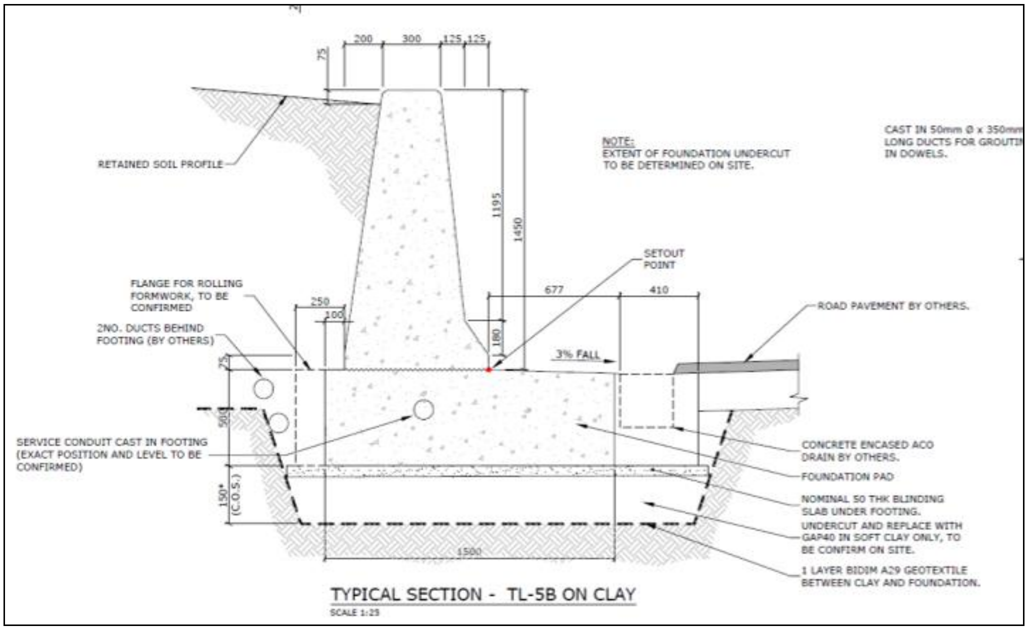

Figure 4: Alternative foundation design

Variable ground conditions in the area

Investigations during the design stage indicated that the basalt was competent along the project site with varying levels of clay and voids. Our previous works in this area showed that there were two possibly three lava flows through this area. This meant that the edge of each flow crossed each other and the basalt rock was unpredictable and variable. This means that the level of basalt was sporadic based on the edge of lava flow and depending on the location.

Due to the basalt being challenging and changing along the line of the piles, the new design removed the requirement that relied on the strength of the basalt. However the storm water design required soak holes (13 in total). This was based on the existing stormwater system being at or near capacity and all new runoff was to be managed within the project. The stormwater soakholes are entirely dependent on the strength and porosity of the basalt. The more porous or voided the basalt the better the soakage.

The level of the basalt also determined the productivity of the excavation. If the basalt is close to the road surface, it requires rock breaking using a digger. This method of rock breaking consumes a significant amount of time. If the basalt level is lower, the excavation becomes easier. However the lower basalt levels did not meet the assumptions of the design. Figure 5 shows the basalt at a high level being broken and the proximity to the motorway.

Figure 5: Different ground condition

Operational requirement (both motorway and rail corridor)

SH1 from the Ellerslie-Panmure roundabout to Green Lane interchange is one of the busiest motorway sections in New Zealand. This section of the motorway suffers prolonged traffic congestion before and after peak hours. The contractor was only allowed to close the motorway after 10 pm and all works to cease by 4 am so that the motorway was fully operational by 5 am. In addition to the restricted road closure on the motorway, the contractor could not affect any trains that run through the project unless it is an agreed Block of Line where there are no trains running. The night works require Isolations so that the plant can operate with the 4.0 metres MAD distance. Isolations are only available from midnight to 4 am. This reduces working time on the shift with plant to only 4 hours.

The challenge has been to ensure that the motorway, railway and the train station remains operational at all times, refer Figure 6 for road and rail proximity.


Figure 6: Rail and Road Operational Requirement

With the limited access the contractor has to plan their work for the different access types. As each shift is critical to the programme, the contractor would have to wait for 24 hours if they did not complete the required work within the shift. In some instances the contractor would need to wait for a week if they do not complete the required works due to the approval timeframe for a full closure of the motorway.

Discussion

This project started in 2010 with Stage 1 being completed in 2012. With the introduction of the electric trains and the livening of the overhead wires, the risk and challenges to the project have increased exponentially. As the first project working with the Auckland 24 kV live AC current network, it became apparent that we were going to be a test case for KiwiRail. This also meant that the procedures to work had to be tested and approved.

The contractor’s methodology from the start of the construction, precluded access from the motorway as this was already a bottleneck during the peak hours that extended to most of the day. There were a number of issues whilst working during the Block of Lines that required an innovative way of trying to work from the motorway. If the BoL’s were only over long weekends, the programme would not be achievable. The working space was the major hindrance to completing any works while the motorway and the rail were operational. Getting approval from NZ Transport Agency and the AMA for using the orange temporary marking, narrowing the lanes to 3.25 metres and installing W-Section temporary barrier was the step change required to progress the project.

The contractor has operated four crews, two at night and two during the day, in order to meet programme. Each shift is dependent on the previous shifts work completion. In order to facilitate this sequencing, Last Planner has been used to ensure that the process is met.

As from the challenges discussed above, this project is unique in every sense with a multitude of criteria to be satisfied simultaneously. At the forefront of this project is a Health and Safety culture from bottom up that ensures everyone goes home safely. All decisions have been guided by the Project Charter that places Health and Safety above all else.

The alternative design and the practical changes to methodology and working from the motorway will see this project completed ahead of completion date.

Conclusion

This paper set out to show how the Ellerslie Widening project has been delivered under tight constraints. The constraints are not time and money but physical and environmental. Each step of the design and construction was in collaboration with the key stakeholders, operating either side of the project. Their involvement into innovation and mitigation has been the success of the ideas that have been borne out of necessity to complete the project yet still meet the project objectives. With all these challenges the project is targeting early completion and within contract budget.

References

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Acknowledgments

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