Case Study:
Tonkin & Taylor and Beca Design JV
– Puhoi to Warkworth motorway

AUCKLAND MOTORWAY EXTENSION NORTHLAND REGION, NEW ZEALAND
THE PROJECT

The Pūhoi to Warkworth project is an 18km motorway extension, to provide a better connection between New Zealand’s largest city, Auckland, and the neighbouring Northland region. With an estimated cost of more than NZ $700m (over 25 years), it is a key investment in the region’s infrastructure. The aim is to improve the safety, reliability and resilience of the state highway.

In May 2015, the NZ Transport Agency announced that they would proceed with construction under a Public-Private Partnership (PPP). Under the PPP contract, the Northern Express Group (NX2) will finance, design, construct, manage and maintain the Pūhoi to Warkworth motorway for the 25 years that will follow the expected five-year period to build the motorway. Full ownership of the highway will remain with the public sector. NX2 have sub-contracted the construction to a Construction Joint Venture (CJV) between Acciona Infrastructure and Fletcher Construction. In turn, the CJV is subcontracting design work to a Design Joint Venture (DJV) of two Australasian engineering consultants, Beca and Tonkin & Taylor (T+T).

Both Beca and T+T have a strong presence in New Zealand and understanding of local conditions. Detailed design work started in late 2016 and the motorway will be open for traffic in late 2021.

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Stuart Cartwright, Senior Engineering Geologist, Tonkin & Taylor
THE SETTING

The population of Auckland has grown to over 1.5 million while the Northland region is expected to reach a population of 171,000 by 2031. Warkworth is classed as a major growth centre of the Northland area. 19,700 cars a day were using the route in 2012 but this is set to rise to 31,300 cars a day by 2026, so with this growth, the road to and from Auckland requires a faster and more economical route to support it.

In addition, the safety factor is also a key consideration as several fatal crashes have occurred between Pūhoi and Warkworth in recent years, some of which were head-on collisions. Therefore, a separated motorway with a central median barrier and improved road design will greatly improve safety.

The DJV originally used Leapfrog in the tender phase of this project to create a 3D geological model of the route. The 3D geological model was imported into the “OpenRoads” motorway geometrics modelling software. Having the geometric design model simply incorporated with the 3D geological surfaces allowed the slope profiles and cut and fill quantities for different alignments to be quickly and easily compared. This allowed optimisation of the geometric model to be undertaken to balance the earthworks mass haul for the project, to assess the most cost-effective alignment for the motorway.

The project requires more than:

- 7 million cubic metres of earth to be cut and
- 5 million cubic metres to be filled,
- 7 bridges to be constructed,
- 3 of which are large viaduct type bridges.

A suitable project-wide ground model was required as a basis for geotechnical design of the proposed earthworks and structures.
The 18km extension of motorway is a large and complex project, where the road corridor cuts through steep hill country with numerous steep sided valleys, which are often filled with soft alluvial sediments. The final design requires several significant road cuttings and embankments to be created, with more than 7 million cubic metres of earth to be cut and 5 million cubic metres to be filled. The project also requires 7 bridges to be constructed, 3 of which are large viaduct type bridges. A suitable project-wide ground model was required as a basis for geotechnical design of the proposed earthworks and structures.

Understanding the material makeup of the ‘Mass-Haul’ balance on this type of project is crucial, as earth extracted from one part of the construction can be used to fill in another part of the site, providing it is of sufficient quality. The aim is to not only reduce amount of wasted material but understand what that material is comprised of and therefore how it can be used appropriately - saving money and time.

Environmental considerations were a key aspect of the project as the alignment traverses greenfield land, some covered in native forest. Approx. 162 hectares of vegetation are to be cleared and then a significant tree planting programme is taking place. So, minimising the cut and fill “footprint” is important to ensure only the minimal number of trees are removed to reduce the impact to the surrounding environment.

THE RESPONSE

The DJV turned to Leapfrog Works as their modelling tool of choice. Leapfrog Works is an implicit 3D geological modelling solution that enabled the DJV to more accurately define the geometry of the cuts. “Leapfrog really helped us on what has been a significant and challenging project. The length of the proposed motorway and its alignment through such steep topography made the ground model development challenging. The contact surface between the weathered Pakiri Formation soil and underlying unweathered rock, was critical for assessing likely cut slope profiles and excavation footprints”, said Stuart Cartwright, Senior Engineering Geologist, Tonkin & Taylor.

Detailed design started in October 2016 and is ongoing. The team started collecting ground investigation data and used this to input into the model. Chris Monk, Engineering Geologist, Tonkin & Taylor said, “There were 3 areas of focus for our geotechnical model: North, which showed low-lying topography; Central, which has significant cut and fill embankments and; South, which contained two viaduct structures. So, it was important we could use a modelling tool that worked flexibly to work around the different geology and surface types to give accurate outputs. We were able to continuously update the model as new investigation data was produced. We modelled 210 CPT’s and brought in data from 420 boreholes, 355 hand augers and 220 test pits. Having a dynamic model that evolves as new data is provided has saved the team time from not having to re-create a new model every time, leaving us more time to focus on the analysis.”
THE OUTCOME

The DJV has been able to produce more accurate 3D surfaces as a consequence of using Leapfrog Works. The more accurate the interpretation of the geological model, the better the outcome of the design. The team were able to better highlight the risks and uncertainties around the model to the other project staff.

Leapfrog Works has transformed the way that the Geotechnical team have worked. This solution has meant that the geological surfaces have been able to be mapped by a geologist, rather than engaging a CAD technician to work alongside a geologist, so it has been a smoother process. As project engineers needed sections, they were able to come straight to a single point of contact to quickly create the desired section, rather than have to draw something, then request a CAD technician to create this afterwards. This has saved time and reduced the effort in having to re-produce work.

The Geotechnical team was able to leverage the great visualisation of Leapfrog Works to bring together and better communicate across such a wide range of project stakeholders including the CJV, quantity surveyors, surveyors and geotechnical engineers and bridge designers. “By being able to show the model in 3D and cut sections at any desired location instantaneously enabled others to visually understand the geological conditions of the site with much better clarity. In the past we would have gone with paper sections, but the 3D model outputs and graphical interface changed the way we communicated and collaborated”, said Stuart Cartwright.

As major infrastructure projects become increasingly large and complex with multiple stakeholders, having a 3D ground model to support the understanding of the geology allows geotechnical teams to improve efficiency of design. Easily maintaining a dynamic model over the course of the proposal and design is transforming the way ground engineers are working. This is a real step forward to enabling this industry become more responsive in an increasingly digital world.

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Chris Monk, Engineering Geologist, Tonkin & Taylor
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