A DISCUSSION ON STRENGTH GAIN FACTORS FOR SOIL UNITS IN THE UPPER NORTH ISLAND

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Session 6A, Heaphy 2&3, July 9, 2024, 10:30 AM - 12:30 PM

The Cone Penetration Test (CPT) is routinely used to obtain insitu data and to assist in geotechnical analysis and design activities for construction projects. CPT data is also used commonly to evaluate liquefaction potential using empirical correlations developed over the last 50 years using either in-situ or laboratory test data from case histories involving very young soil deposits.

Through recent studies, it is shown that liquefaction resistance is increased due to factors such as aging and bonding through the contribution of soil microstructure. To account for this contribution of soil microstructure to liquefaction resistance, several methods are available to derive a strength gain factor, KDR, by combining conventional CPT with shear wave velocity testing.

This research will look at strength gain factors calculated using two methods and a database of seismic CPTs (sCPT) performed in the Upper North Island. The range of strength gain factors derived for several geological formations will be presented and along with an interrogation of any general trends observed.

A FRAMEWORK FOR DEFINING YIELD ACCELERATION AS THE SEISMIC CAPACITY OF SLOPE STABILITY: INSIGHTS FROM DIVERSE METHODOLOGICAL APPROACHES

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Session 3C, Brooklyn 1, July 8, 2024, 1:30 PM - 3:30 PM

This study introduces an innovative framework aimed at defining the yield acceleration as the key determinant of seismic slope stability, drawing upon diverse methodological approaches.

Focused on a Wellington complex Greywacke terrain of high seismicity and adjacent to the Wellington fault, the research endeavours to enhance comprehension of seismic slope stability phenomena. Central to this framework is the integration of various methodologies, including the use of SLIDE2 and SLIDE3 software for comprehensive 2D and 3D slope stability assessment. The study adopts a multifaceted approach, integrating both simplified and more advanced tools, such as the pseudo-static method, Newmark block method, and non-linear time history finite element modelling. By considering seismic events with a return period of 2500 years, the framework facilitates the ‘prediction’ of slope displacement during extreme seismic activity, thereby enabling a nuanced assessment for the performance of the slope.

A primary focus of the study lies in the derivation of the yield acceleration coefficient, a critical parameter in determining the performance of a slope or for estimating the slope stability under seismic actions. This coefficient is derived through meticulous analysis of various methodologies, reflecting the intricate interactions between slope deformation and seismic forces.

The framework developed in this study offers valuable insights into the performance of slopes under seismic loading from different perspectives, thereby providing a robust method for the development of mitigation strategies in seismic hazard-prone regions.

A FRAMEWORK TO ESTIMATE THE CARBON EMISSION OF BRIDGE STRUCTURES

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Session 6B, Brooklyn 2, July 9, 2024, 10:30 AM - 12:30 PM

The environmental impact due to the construction of infrastructure has become a growing concern, with particular attention paid to carbon emissions. The Climate Change Response (Zero Carbon) Amendment Act 2019 set out domestic greenhouse gas emissions reduction targets for New Zealand, including reducing net emissions of all greenhouse gases (except biogenic methane) to zero by 2050. This paper presents an efficient framework to estimate the carbon produced by a piece of infrastructure. The framework uses 3D parametric modelling to generate the structural element type and compute the material volume depending on the geological contour and ground profile. Once the material type and quantity are defined, the potential carbon emissions during the whole life cycle of the structure can be calculated by considering emissions due to material used, transportation, construction method and waste for each element. By employing parametric modelling techniques, engineers can evaluate various design options, allowing for the identification of environmentally friendly alternatives that reduce carbon emissions. A worked example of a multi span bridge will be presented in the paper.

ACCOUNTING FOR CARBON IN BRIDGES - A CAUTIONARY TALE

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Session 3B, Brooklyn 2, July 8, 2024, 1:30 PM - 3:30 PM

Globally, there is a concentrated effort by various countries to meeting their carbon emission reduction targets, which for New Zealand is taken as being 50% carbon reductions by 2030 and achieving net zero by 2050; as part of meeting our obligations in addressing the Climate Crisis. One of those efforts in the transport sector is reducing the embodied carbon when designing new bridges. Currently efforts are underway to develop low carbon steel and concrete alternatives, however, the expectations that such solutions are unlikely to be commercially available before 2030. As such, a prominent low carbon solution is timber, whose biogenic carbon sequestration during the tree-growth cycle makes it an ideal solution. Whilst timber is being used in bridges, either as a steel/timber hybrid or a standalone timber solution, the question was raised on whether it is possible to maximise the benefits of all 3 materials in the same structure.

This thought-provoking presentation delves into the intricacies of steel/timber hybrid solutions with concrete, by comparing the cumulative carbon profiles of a conventional composite steel/concrete ladder deck bridge with a hybrid alternative, that utilises a steel/concrete ladder deck with steel main girders and glulam cross girders. The presentation will outline current carbon life cycle assessment assumptions and “best practice”, and in turn highlights its limitations and risk when considering carbon in bridges. Further, a discussion on considering durability and detailing will be given, and the presentation concludes with lessons learnt to mitigate those risks and question the meaning of designing a truly sustainable bridge.

AN OVERVIEW OF COMING UPDATES OF AS 5100.4 AND AS/NZS 5100.6

Mr Jamil Khan[1], Mr Mike Beamish[1]
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Session 2B, Brooklyn 2, July 8, 2024, 10:30 AM - 12:30 PM

The current version of Australasian Bridge Design Standard 5100 series was released in 2017 and is now going through an update. The proposed changes were issued for public comments on 12 April 2023. The public feedback was reviewed, and the comments were either addressed in the amendments or responded to if the comments were not appropriate to address in the proposed amendments. These standards are being finalised after addressing the public comments, AS 5100.4 was published in December 2023 and AS/NZS 5100.6 is scheduled for publication in 2024. This presentation will provide an overview of the upcoming changes in the following two standards:

1. AS5100.4 Bridge Design, Part 4: Bearings and deck joints
2. AS/NZS 5100.6 Bridge Design, Part 6: Steel and composite construction

AS 5100.4 Bridge Design, Part 4: Bearings and deck joints
AS5100.4 is amended by making some changes in the clauses 7.5, 13.1.A, 13.2, 15.2,17, 19.3.4, and D4.2. The presentation will give an overview of these changes and compare the proposed changes with existing provisions in the standard to clarify the changes.
AS/NZS 5100.6 Bridge Design, Part 6: Steel and composite construction
AS/NZS 5100.6 is the only joint Australian and New Zealand design standard for bridges, which is going through significant changes to address Australian and New Zealand specific needs and the material properties. Some of the key changes in AS/NZS 5100.6 are:

- The entire section 13 “Fatigue” is re-written to fix the errors and issues with existing 2017 version of the standard.
- A new section 16 “Fabrication” has been included in the standard.
- Another new section 17 “Erection” has been introduced in the standard.
- A new Appendix M “Selection of materials for the avoidance of lamellar tearing” is added in the standard. Lamellar tearing is a weld-induced flaw in the material, which becomes evident during ultrasonic examinations.
- Several other clauses have also been amended to address some of the mistakes in the 2017 version and align this standard with other NZS standards like NZS3404 and NZS 3101.

AURAKI STREAM ROAD RETREAT: DESIGN AND CONSTRUCTION OF A 55M CUT SLOPE ALONG SH4

Mr Christoph Kraus[1], Mr Paul Horrey[1]
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Session 7C, Brooklyn 1, July 9, 2024, 1:30 PM - 3:30 PM

On 19-20 June 2015 heavy rainfall caused extensive flooding and numerous landslides in the Taranaki, Whanganui, Rangitikei and Manawatu districts. Numerous roads were damaged or closed by landslides and flooding, including the State Highway 4 (SH4) corridor between Whanganui and Raetihi which received approximately 140mm of rainfall in 48 hours.

One of the last sites affected by the 2015 storm to be remediated along SH4 was the Auraki Stream Road Retreat project (‘Site 15’), located about 55km north of Whanganui. During the 2015 storm, flooding of the Mangawhero River resulted in the erosion of the bank below the road, reducing SH4 down to one lane at this site. Given the complexity of the site, an options assessment of several potential remedial solutions was developed. Five potential options were considered: a two-lane retreat which involved cutting into the steep slope on the southbound side of the road, a river diversion and reinstatement of the road at its previous location, and three retaining wall options.

The two-lane retreat option was chosen as the preferred solution. The design involved constructing a 55m tall cut slope and excavating about 120,000 m3 so that the road could be retreated by up to 15m onto a rock platform, thereby improving the future resilience of SH4 at this location. Construction commenced in late 2021 and the cut slope was completed in 2023, exposing spectacular geology, including three faults, Pleistocene alluvium including boulder lenses, and Tertiary sedimentary rocks. Additional ground support was required at several stages during cut construction due to the ground conditions encountered. During the design, consenting and construction phases the project team worked closely with local iwi in a co-design.

This presentation will cover (i) ground model development, (ii) the optioneering process and how the preferred solution was chosen given the constraints of the site; (iii) the detailed design of the cut slope; (iv) construction of the cut slope; and (v) the co-design completed with iwi. As part of the presentation, we will provide a summary of the geology encountered in the cut slope, and the ground engineering solutions applied.

We will conclude by providing some learnings and recommendations applicable to future high cut slopes in the Tertiary sediments which underlie much of the lower/central North Island.

AUSTRALIAN AUTOMATED ACCESS SYSTEM DEVELOPMENT AND THE POTENTIAL BENEFITS FOR NEW ZEALAND

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Session 4B, Brooklyn 2, July 8, 2024, 4:00 PM - 5:30 PM

Since its development in the 1980s, Opermit has remained New Zealand's preferred system for heavy vehicle access decisions for state highway and local authority bridge structures. While historically a world leader in automation and assessment accuracy, there are still several opportunities for further enhancement. Fully automating decisions could eliminate the need for costly permitting reviews, while enabling real-time access decisions that could optimise freight efficiency network wide.

Currently, Austroads is working with road managers to implement the National Automated Access System (NAAS), aiming to improve heavy vehicle access decision-making for road managers in Australia and New Zealand. This system holds the potential to bring fully automated, real-time access decisions to New Zealand.

To understand the potential requirements of the NAAS, WSP conducted an investigation into current structural assessment and heavy vehicle access decision making practise across Australia and New Zealand. While the specifics of NAAS are still in flux and various adoption methods are on the table, this presentation zeroes in on the key findings from the study and their potential impact on New Zealand's permitting processes.

This presentation will dive into the feasibility of a staged NAAS adoption, the evolution of approaches over time, the perks of plug-and-play API interfacing, phased adoption based on necessity, and other critical factors. In addition, it will tackle topics including data independence from load factors, retrospective sensibility checks, provisions for manual reviews, ensuring traceability, and the vital role of comprehensive guidance documentation.

BRIDGE MANUAL HN LOADING UPDATES

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Session 7B, Brooklyn 2, July 9, 2024, 1:30 PM - 3:30 PM

The 2022 amendment to the Bridge manual introduced updated vehicle live loads for the evaluation of bridges and culverts, while noting that work on development of a new vehicle live load model for design is continuing.

The existing Bridge manual design live load model for a lane of normal traffic (HN-72) uses one short 2-axle vehicle with accompanying uniform load live to represent nominal vehicle live load effects. Development work for the evaluation loadings demonstrated that unfactored negative moment effects for single HPMV or pairs of vehicles travelling in the same lane can be substantially greater than those based on the HN live load model used for design. This implied that the existing HN design loading with one pair of HN axles has significantly lower margins over the effects of conforming HPMV on continuous spans than for simply supported spans.

The amendment to the HN (normal) loadings adds a second pair of HN axles positioned in the adjacent span for calculation of negative moment effects (relevant for span lengths in the 25m to 60m range). For shorter continuous spans the effects of long vehicles are represented by a new loading arrangement using two tandem axle groups plus the standard uniform load. For these double HN and double tandem loadings, a 0.90 reduction factor is applied.

Additionally, the application of multiple lane reduction factors uniformly across lanes is changing to adopt the accompanying lane factor (ALF) approach, as used for the new evaluation loadings and as specified in AS5100.2.

The presentation for the loading amendments will cover the background to these changes to the design live loading model and compare updated design load effects with the existing design load and HPMV evaluation load effects.

We will also present outcomes of trial application of the amended design live loads to two recent bridge designs – a continuous Super-T bridge structure (35m span) and a 3-span continuous steel girder bridge (45m, 50m, 42m spans).

BRIDGES TO PROSPERITY - ELIMINATING POVERTY DUE TO RURAL ISOLATION THROUGH FOOTBRIDGE NETWORKS

Ms Hanna Davidson[1], Thomas Cooper[1]
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Session 8 & Conference Closing, Heaphy 2&3, July 9, 2024, 3:35 PM - 4:40 PM

Bridges are vital to connecting communities all over the world. The access they provide connects people with places essential to their daily lives, whether that be education, employment, or healthcare, as well as supporting economic development by reducing travel time for trade and commerce.

Bridges to Prosperity is a non-profit organisation that partners with local governments to connect rural communities via pedestrian trail bridges. Their mission is to use bridges to address rural isolation as one of the root causes of poverty. By constructing rural trail bridges, they can provide communities with safe access to critical services, improving safety, livelihoods, and wellbeing.

WSP Global collaborates with Bridges to Prosperity by sending volunteers from around the world to contribute to the construction of trail bridges. Through this partnership last year, Hanna Davidson was one of a team of ten who worked together with local community members to build a bridge that now provides safe access over the Ruhondo River in Gicumbi, Rwanda.

The opportunity was a unique experience to work alongside the eventual users to construct the bridge. It gave insight into the level of transport we take for granted seeing how one bridge impacts a community of people so significantly. During the project, the team lived within the community and met people each day. This gave a greater understanding of the history of the area, and the risks before the bridge's construction.

This presentation will cover lessons learned through experiencing the construction of a rural trail bridge, its impact on the local community, and the influence this has had on an emerging bridge engineer.

BRIDGING THE GAP: SPACE TECHNOLOGY FOR LANDSLIDE DETECTION AND TRANSPORTATION NETWORK MONITORING IN NEW ZEALAND

Andrew Lees[1], Dr Skevi Perdikou
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Session 3C, Brooklyn 1, July 8, 2024, 1:30 PM - 3:30 PM

Landslides are one of the major natural disasters globally, causing enormous economic impacts and loss of life every year. Particularly in mountainous regions, where transportation networks such as roads and rail corridors traverse cut slopes, landslides pose a significant threat to infrastructure assets, including bridges. Between 1998 and 2017, an estimated 4.8 million people and more than 18,000 deaths in low-income countries were affected by landslides. Recognising the issue early on holds the potential to prevent at least 90% of these losses, underscoring the importance of prevention measures.

New Zealand, with its diverse landscapes and frequent seismic activity, faces common occurrences of landslides due to its mountainous terrain, loose volcanic soil, and earthquake activity. In recent years, the use of InSAR (Interferometric Synthetic Aperture Radar) has increased for geohazard assessment, proving particularly effective for landslides. The availability of radar imagery, especially from the European Space Agency Copernicus Programme Sentinel-1 mission, provides valuable information for detecting active landslides remotely.

In this study, we present the results of InSAR analysis on active landslides in New Zealand, focusing on their impact on transportation network corridors, including bridges. We demonstrate how space technology can effectively identify areas at risk, facilitating proactive mitigation efforts and maintenance prioritisation. The developed technology serves as a decision-making tool for the proactive maintenance of transportation networks, including critical bridge infrastructure, in New Zealand.

CANARY - AUTOMATED TRIGGER ACTION RESPONSE PLANS FOR A CHANGING WORLD

Mr Jeremy Waldin[1], Mr Willis Macbeth[1]
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Session 7A, Heaphy 2&3, July 9, 2024, 1:30 PM - 3:30 PM

Events in recent years have highlighted the challenges that asset owners face due to escalating weather extremes and financial pressures. Recognising this fact, in 2022 the NZ Transport Agency Waka Kotahi (NZTA) developed a Guidance Document for Trigger Action Response Plans (TARPs) for Bridges. This document provides practical advice and examples on how to develop and use TARPs in the protection of both bridges and other highway assets from flood, live load, rockfall, landslides and other natural hazards and risks.

WSP's "Canary," system uses the fundamentals of this Guidance Document and provides an example of how smart, automated TARPs can be used to proactively manage risk to vulnerable infrastructure. Canary integrates GIS dashboards, remote sensors, weather forecasting, and technical know-how to implement and automate TARPs. These automated TARPs empower asset owners to make informed, data-based decisions before, during, and after natural disasters. By enhancing stakeholder awareness, improving preparedness, and issuing advanced warnings at an asset level, Canary can reduce the potential impacts of severe weather events, protect life safety and ensure business continuity.

This presentation will include recent examples of the successful application of Canary, including: mitigation of rockfall risk on the vulnerable Kaikoura Coastline; protection of the Ashburton River Bridge on State Highway 1S in the South Island; and management of vulnerable bridges, structures and slopes on the East Coast of the North Island following the effects of Cyclone Gabrielle.

Key conference topics: Innovation, Asset management practice; technology in structures; standards and guidance; project case studies; emergency & disaster response in horizontal infrastructure.

CASE STUDIES ON BRIDGE REPAIR AND DESIGN STRATEGIES AFTER CYCLONE GABRIELLE

Dr Sabina Piras[1], Dr Johan Klopper[1], Kwan Chin[1], Dr Jono Watkins[1]
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Session 4A, Heaphy 2&3, July 8, 2024, 4:00 PM - 5:30 PM

In February 2023, Cyclone Gabrielle struck the North Island of New Zealand, leaving a trail of destruction in its wake and posing significant challenges to network availability, in large part caused by bridge infrastructure failure. Several bridges, required substantial repairs before traffic could resume their use. The damage and structural failures observed aren't typically seen in smaller-scale flood events or even during moderate seismic activities. By synthesising these observations, insights are provided that could influence future design and maintenance strategies to enhance durability and bridge resilience.

This presentation will primarily discuss two case studies, which required significant repairs as a result of Cyclone Gabrielle. The presentation will detail the damage observed, assessment methodologies employed, and repair strategies implemented to hopefully facilitate future infrastructure resilience planning.

Awatere Bridge is located in Te Araroa on East Cape Road and spans the Awatere River. The bridge was designed in 1959 and consists of 6 spans. Pier B of the Awatere Bridge was rotated and displaced due to the probable shear failure of the pile-to-pier interface as a result of Cyclone Gabrielle. As part of the emergency works, temporary brackets were installed on the pier to support the superstructure beams from de-seating. This temporary solution allowed for light vehicle traffic to use the bridge. A permanent repair solution included the construction of two new columns/piles that supported temporary crossbeams while the damaged pier was demolished and a permanent crossbeam was installed. To maintain traffic over the bridge, a Bailey Bridge was employed to span over the affected pier.

Redclyffe Bridge is on one of the arterial routes between Napier and Hastings. The bridge was constructed in 1932 and comprises of 18No. reinforced concrete spans divided into 4No. continuous span sections. Severe hydraulic load from flood water, as well as a debris raft, resulted in failure of the central two continuous span sections and significant localised vertical beam cracking in the upstream and central beams as well as transverse deck cracking of approach span sections. Analysis on approach span beams included shear capacity and moment effect checks due to concrete cracking and likely yielding of existing longitudinal reinforcing steel. Repairs comprised of concrete crack injection on the beams and deck. The temporary bridge, with a design life of 5 years, comprising of existing continuous approach spans and temporary staging structure in the central portion is currently operating successfully at reduced live load levels.

CASE STUDY: SH1 NIMT BRIDGES - BORED PILES WITH A BASE DRIVEN PLUG

Mr Blair Matheson[1]
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Session 7A, Heaphy 2&3, July 9, 2024, 1:30 PM - 3:30 PM

A common foundation type for bridges in New Zealand are bored piles due to their high seismic performance, reliability and ease of construction. The preferred bearing strata for these piles is the underlying rock which provides high geotechnical capacities and stiffness (i.e. low settlements). However, ground conditions vary across New Zealand and rock is not always found at reasonable depth. The geologic setting in New Zealand provides deep sequences of alluvium in many locations formed by alluvial processes, faulting or a combination of both.

There are several ways to design foundations for deep alluvium sites. In some situations, there is an opportunity to improve the ground so that a shallower piled foundation can be adopted. This can be achieved via pile construction techniques such as driven piles, base driven plugs, base grouting.

This presentation comprises a case-study on the design and construction details of bored piles with base driven precast concrete plugs for the North Island Main Truck (NIMT) bridges on the Papakura to Bombay, Stage 1B1 project. The design and construction overcome the difficult ground conditions to reduce bored pile lengths by approximately half, 50+m to 25m length. The project had other unique constraints such as the nearby vibration sensitive infrastructure including NIMT railway tracks and 1.2m dia. WaterCare pipeline.

This presentation will be broken into two parts. First part will highlight the local geology and detail the design approach we took, including our collaboration with the peer reviewer. The second part of this talk will present the construction activities and focus on geotechnical quality assurance testing and compliance with NZTA Bridge Manual. The aim of this presentation is to present a case study and show practitioners a NZTA Bridge Manual compliant design for piled foundations adopting a base driven plug within alluvial soils. The presentation will also include limitations of this method and our risk-based design approach.

CENTRAL HAWKE'S BAY CYCLONE GABRIELLE RESPONSE – LESSONS LEARNT COMBINING LOCAL KNOWLEDGE AND NEW TECHNOLOGY

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Session 7C, Brooklyn 1, July 9, 2024, 1:30 PM - 3:30 PM

Central Hawke's Bay District Council faced significant damage when Cyclone Gabrielle made landfall in February 2023, causing widespread damage to infrastructure and private property. The cyclone inundated and undermined bridges, triggered landslides, and disrupted vital transportation links, isolating the region with only SH2 south remaining accessible. A State of Emergency was declared on February 14, 2023, marking the beginning of the response efforts.

To streamline response efforts, a GIS survey tool used in previous response events was deployed, it was populated with the existing Road Assessment and Maintenance Management (RAMM) database and dispatch system. This tool facilitated rapid and repeatable records of bridge inspections, landslide assessments, and provided clarity for the overall response coordination. A live dashboard provided real-time updates on road closures, inspection progress, and fault resolution, simplifying reporting procedures and enabling resource allocation. This gave clear early-stage triaging of the network.

The ease of recording information meant that numerous and comprehensive records could be gathered. However, these records, while valuable, were still an uncalibrated snapshot in time and required follow-up. This included comparing the most recent inspections, historical information and as-built data – a manual time-consuming process. Over the following weeks and months these inspection records were worked through with critical faults becoming clear only when the as-builts and bridge inspections records could be located and reconciled. Often, this brough critical urgent issues to light that were initially triaged as lower priority.

This paper aims to discuss the actions and decisions that occurred in the response stage and reflecting on those decisions and what improvements could be to prepare or responding to a similar emergency event. This will include, recording faults and repair options, dispatching contractors, system access to allow collaboration between consultants, and how to incorporate local knowledge and existing records so that they can be drawn upon in the field and during a response event. Once the initial response was completed, design work for less urgent and stable sites was undertaken. This paper also discusses how to best stage this work, and set up a design philosophy suitable for the works being undertaken.

COMPLEX ROCKFALL MITIGATION AND GROUND ENGINEERING - CONSTRUCTION AND MAINTENANCE LEARNINGS

Mr Tim O'Toole[1], Mr Tim O'Toole[1]
[1]Rock Control, Christchurch, New Zealand

Session 6C, Brooklyn 1, July 9, 2024, 10:30 AM - 12:30 PM

New Zealand is known for its dynamic and unstable landscape with a wide variety of geotechnical conditions. Each has a range of solutions that are best suited for based on performance, constructability and subsequent maintenance.

Using the Kaikoura Coast and SR10 Canopy structure as an example of complex construction,   to discuss the project successes, areas of improvement and the value of Early Contractor Involvement (ECI). This project required all standard protection measures to be installed along with the installation of a NZ first Canopy structure . this makes it unique. We will also discuss other common challenges faced by contractors installing these type of structures including equipment restrictions and access considerations.

With a large number of systems now installed nationwide the maintenance completed to date post event has given valuable learnings. Most methods have been attempted along the Kaikoura coast and kit bag of techniques and tools are now well understood. We will discuss the methods used as well as the modifications made to structures to improve maintenance activities.

CONSTRUCTING HIGHWAYS OVER ACTIVE NORTHLAND ALLOCHTHON LANDSLIDES - TWO EXAMPLES ON THE O MAHURANGI PENLINK PROJECT

Ms Susan Tilsley[1]
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Session 3C, Brooklyn 1, July 8, 2024, 1:30 PM - 3:30 PM

The O Mahurangi Penlink Project (OMA Project) between Redvale and Whangaparaoā involves significant earthworks and four overbridges through the toe of the southern-most block of Northland Allochthon (Allochthon) in the upper North Island. The fabric of the Allochthon is widely considered chaotic to broken on a small scale. However, delineation of the various lithological blocks and thrust sheets within the Allochthon Complexes can be recognised geomorphically and collaborated by intrusive investigation data. Where exposed, these geo-structures have been found to be infilled with thin bentonitic mudstones, similar-to 'slow-slip' type tectonic movements.

Two active landslides within the Allochthon were recognised in both the early stages of the OMA Project and confirmed during detailed design. These are located below and beyond the project designation. Monitoring of instrumentation and observation during initial earthworks have revealed the complexity and relatively large-scale of the landslides. Typically used design tools to inhibit movements that extend beyond the NZTA-controlled work areas are limited and the current design requirements of the NZTA Bridge Manual (BM) can further constrain innovation.

A risk-based approach to design could be introduced for static assessments of large-scale geohazards rather than solely relying upon deterministic techniques. This could provide outcomes that are beneficial to a range of stakeholders and align with seismic hazard assessments and maintenance practices on existing highway networks.

CRACKED BUT NOT BROKEN - CREATIVE AND SUSTAINABLE REPAIRS TO CRACKED CASTELLATED GIRDERS

Mr Tomasz Mirocha[1]
[1]Beca Ltd, [2]NZ Transport Agency

Session 3B, Brooklyn 2, July 8, 2024, 1:30 PM - 3:30 PM

Discovery of cracks within the castellated girders of the 60-year-old Manganuku Bridge, located on SH2 between Opotiki and Gisborne, presented an urgent engineering challenge. This was compounded by Cyclone Gabrielle causing concurrent closure of all alternative routes connecting Gisborne, increasing reliance on SH2. Temporary repairs and performance monitoring provided a short-term solution to a highly complex problem. Recognizing the lack of dedicated standards for evaluating the unique behaviour of continuous composite castellated girders, we looked to international practices for insights and developed tailored assessment procedures for this type of bridge.

We employed an advanced assessment methodology comprising a "hybrid" finite element approach that combined a 3D space-frame with 2D plate elements. This allowed us to accurately capture both global and localized stress patterns. Fatigue assessment proved complex due to its empirical nature, requiring in-depth studies on critical stress concentration factors, traffic history, and the degree of composite action. On-site strain gauge readings and a novel stress traction method calibrated desktop results, providing valuable insight into the behaviour of castellated composite girders.

An options analysis followed, considering strengthening alternatives and full superstructure replacement. Cost-efficiency, constructability, traffic disruption, durability, and embodied carbon footprint drove our decision-making process. The selected strengthening scheme involved infill plates strategically welded within castellations to redistribute stresses, restore capacity, and enhance fatigue resistance. With the strengthening adding under 1 tonne permanent deadload, this solution is lightweight and compact, facilitating on-site installation and minimizing traffic disruptions. By addressing the fatigue vulnerabilities, we have enabled the bridge to remain in service for its original 100-year design life, providing time for future innovations which may enable further life extension.

The Manganuku Bridge project demonstrates the link between asset management and sustainability. This showcases the multifaceted benefits of strengthening over replacement. Proactive asset management coupled with innovative engineering has delivered an optimal outcome that benefits communities, the environment and the tax payer, and enables finite resources to be allocated to proactive management of other critical assets.

This presentation will delve into specific details regarding our assessment methods, creative strengthening design, and the achieved sustainability advantages. The Manganuku Bridge serves as an inspiring case study in meeting urgent infrastructure needs while paving the way for a more sustainable future in New Zealand.

CRL MAUNGAWHAU STATION – A CASE STUDY IN REDUCING CONSTRUCTION EMISSIONS

Mr Anton Stanisich[1], Dr Doug Boddy[2]
[1]AECOM, [2]Link Alliance

Session 2A, Heaphy 2&3, July 8, 2024, 10:30 AM - 12:30 PM

City Rail Link (CRL) stands as the most significant transport infrastructure project in New Zealand, with a budget exceeding $5.5 billion. Central to this project are the twin tunnels linking Waitematā Station to the North Auckland Line at the revamped Maungawhau Station. Moreover, the project includes the construction of two new underground stations, Te Waihorotiu Station and Karanga-a-Hape Station, enhancing access to Auckland's city centre via the rail network. Once in operation, CRL will substantially increases the capacity of Auckland's rail network. With the New Zealand Government aiming for net-zero carbon emissions by 2050, projects like the CRL play a vital role in achieving this ambitious target.

The presentation will delve into the strategies employed throughout the design and construction phases to reduce greenhouse gas emissions associated with the construction of Maungawhau Station, tunnels, bridges, and associated earthworks. This will cover both reducing embodied carbon in materials and minimising energy consumption. The sustainability efforts on CRL have garnered acclaim from the broader industry, and the project has won numerous awards, including the Decarbonisation Outcomes Award (Projects over $20m) at the Building Nations 2050 Impact Awards. Additionally, the project received the highest possible Infrastructure Sustainability Design rating from the Infrastructure Sustainability Council, attaining a score of 93, corresponding to a "Leading" rating. This presentation serves as a valuable case study for reducing greenhouse gas emissions in infrastructure projects.

CYCLONE GABRIELLE EMERGENCY RESPONSE: DATA COLLECTION AND LESSONS LEARNED IN HAWKES BAY

Mr Joe Cant[1]
[1]Beca Ltd, [2]NZ Transport Agency, [3]Higgins

Session 6C, Brooklyn 1, July 9, 2024, 10:30 AM - 12:30 PM

Collecting and triaging the extensive damage to the State Highway Network in the Hawkes Bay region in the days and weeks after Cyclone Gabrielle proved to be a unique challenge. With limited power in the region, communication networks largely down, and access to many sites only achievable via helicopter, simple site inspections and assessments required close collaboration with Higgins and Waka Kotahi (NZTA). Once able to access sites, data collection and visualisation became a particularly important and complex task in the immediate aftermath.

Due to the nature of the damage, inspections across the Hawkes Bay network were distributed due to the pseudo “islands” created by the loss of multiple bridges and unpassable sections of road. After data collection and triaging, key sites were selected to trial the preliminary Waka Kotahi “One Page Desktop Study” that focuses on understanding the cause(s) of failure and the ground conditions, along with providing a sketch cross section and concept repair options. This allowed a standardised way of assessing each site and developed a shared understanding of the issues to allow rapid optioneering and remediation. These desktop studies, along with the visualisation tools, showed a series of similar, repeated fault types, for which standardised ’best value’ solutions were developed. These were implemented across the network to allow much needed aid and reconnection of communities in the region.

With engineering principles applied in a very practical way, heavily relying on the engineering judgement of experience geotechnical professionals, many of the ’best value solutions were able to be incorporated into the permanent design or have been accepted to remain without adjustments, as they provide commensurate or greater level of geotechnical performance than the surrounding network.

These standardised solutions became a crucial part of the contractor’s toolbox, however, required close collaboration with the on-site Geotech Engineers to tailor the solution to the particularities of each site. These ’best value’ solutions provided a flexible, robust and cost-effective emergency response tool that was rapidly deployed across the network.

Further detail and lessons learnt from the initial emergency response and recovery phase of the Cyclone Gabrielle will be shared in further detail during the presentation if selected.

CYCLONE GABRIELLE FLOOD RECOVERY RESPONSE – INSPECTION, CLASSIFICATION AND REMEDIAL

Mrs Natalia Uran[1], Mr Ben Baty[2]
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Session 3A, Heaphy 2&3, July 8, 2024, 1:30 PM - 3:30 PM

The wide-ranging effects of our changing climate were acutely felt across New Zealand in 2023 through multiple extreme weather events; most notably through Cyclone Gabrielle. This event caused major damage across the North Island and prompted a national state of emergency. It left in its wake multiple collapsed bridges and significant damage to both structures and the road network. This severed critical lifeline routes; caused significant disruption to travel and trade; major/high cost of remediation; and tragically, loss of life.

In the days following the event information was scarce, and the East Coast faced considerable communication and logistics challenges. The initial focus of engineering consultants supporting transport authorities was assessing the extent of damage on the ground and identifying safe routes for travel. This involved mobilising inspection teams with expertise into the affected areas, and remote teams to assess, prioritise and design; crucial work aimed at restoring critical transport links quickly and efficiently. Given the scale a new and innovative approach to systems, assessment and coordination was needed, incorporating lessons from past emergencies at the outset to set-up the response for success.

This presentation will focus on the strategic approach and technological innovations implemented in response to the unprecedented challenges posed by the cyclone. This includes damage assessment, prioritization, communication strategies, and the rapid development of technical solutions tailored to specific site constraints. This approach was accomplished while fully understanding and managing risks to ensure the safe and prompt reconnection of communities. It will capture lessons learned that are important to take forward in preparation for future emergencies for transport authorities and consultants alike.

CYCLONES, BRIDGES, AND SUSTAINABLE SOLUTIONS: A PROJECT CASE STUDY OF TWO 80-YEAR OLD RC BRIDGES IN TE TAI TOKERAU

Mr Liang-Shou Wei[1], Mr Andrew Dickson[1], Mr Gavin Gribben[1], Mr Erwin Atienza[2]
[1]Beca Ltd, [2]NZ Transport Agency

Session 3B, Brooklyn 2, July 8, 2024, 1:30 PM - 3:30 PM

The New Zealand State Highway network includes 2800 bridge assets, managed by structures management consultants (SMCs) for NZ Transport Agency (NZTA). Two hundred of these bridges are situated in Northland, with approximately 35% of them being reinforced concrete T-beam bridges constructed over 80 years ago. Waitangi River Bridge and Parapara Bridge are two such bridges built in the 1940's.

This presentation will examine how extreme weather events, increased loadings, and current assessment methods impact asset management processes. The bridges are vital components of Northland's transportation network, playing a crucial role in connecting communities and facilitating safe and efficient transport of people, goods, and services. Consequently, the sustainable management of these assets becomes critical to Northland's people and economy.

This presentation will also aim to describe the proactive methods employed in managing these bridge assets during the floods of 2020 and 2022, as well as Cyclone Gabrielle, ensuring their continued life, and in some cases, extending their functionality. It will specifically focus on addressing longitudinal shear and capacity deficiencies, as well as how the strengthening works aligned with Waka Kotahi's Toitū Te Taiao – Our Sustainability Action Plan.

By sharing these bridge asset management processes, methods and techniques, this presentation seeks to contribute to the ongoing maintenance and optimisation of these vital components of New Zealand's State Highway network.

DEALING WITH PUMICE – LESSONS FROM THE BAY LINK PROJECT, TAURANGA

Dr David Milner[1], Mr Ben Francis[2], Mr Sutejo Tjokro[2], Mr Clive Anderson, Dr David Milner[3]
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Session 6A, Heaphy 2&3, July 9, 2024, 10:30 AM - 12:30 PM

Pumiceous soils of local volcanic origin are commonly encountered in the central North Island, including the Bay of Plenty and Waikato. Pumice can be compressible, crushable, highly erodible, and often has a low elastic modulus, but the geotechnical performance of pumice and pumiceous soils (e.g., slope stability, liquefaction, and bearing capacity) is generally considered to be better than other comparable soils with similar testing results. The nature of pumice particles and the lack of standardised procedures to quantify geotechnical properties (including liquefaction tiggering potential) can make it difficult to characterise. Initial identification of pumice during site investigations can be problematic and accounting for the unique engineering properties and behaviours of pumice in design can be challenging.

This presentation discusses lessons learned from working with pumiceous soils for the Baypark to Bayfair Link Upgrade project (B2B/Bay Link), which is a grade separation project in Mount Maunganui. The project is split into two zones: Baypark in the south/east and Bayfair in the north/west. The project area is underlain by significant thicknesses of dune/beach sand and silty estuarine deposits, all of which are susceptible to liquefaction. Ground improvement was a key element of the project, with three bridges and the associated approaches being supported on improved ground. The primary method selected to improve the ground was densification using stone columns. Densification was achieved at the southern end of the project; however, densification could not be validated following installation of stone columns beneath the northern end of the project. Following extensive investigation, it is considered that elevated pumice content is the primary cause for not being able to validate the stone column densification beneath the northern end of the project.

In this paper we look at the assessments and investigations that were undertaken to identify the pumice and quantify its content. This included examination of existing data from standard tests (e.g., dry density and moisture contents) but also discusses specialised site investigations and testing undertaken following the issues encountered during construction. Specialised testing methods were adopted to quantify the influence of the pumice on the liquefaction triggering potential of the site, and ultimately the final design path chosen to mitigate the effects of its presence on the original design.

DESIGN AND CONSTRUCTION FOR GEOSYNTHETIC REINFORCED SOIL ABUTMENTS (GRS) AND INTEGRATED BRIDGE SYSTEMS (IBS)

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Session 4A, Heaphy 2&3, July 8, 2024, 4:00 PM - 5:30 PM

GRS is a special mechanically stabilized earth (MSE) structure. GRS, like all MSE structures, consists of a facial element, reinforcement, and structural backfill. However, the main salient feature of GRS-IBS is its internal composite behaviour. It provides GRS with internal stability, which deviates from the earth pressure plane of failure (Coulomb) of MSE.

This composite internal behaviour of GRS is due to the spacing of high-strength, low extensible geosynthetic materials in alternating layers, closely and the use of structural backfill. Such an arrangement creates an extremely effective soil-geosynthetic interaction. In GRS, the reinforcement not only serves to resist tensile forces but also functions to restrain lateral deformation of the soil, increase lateral confinement, simulate the effect of cohesion in a granular fill (while maintaining all desirable characteristics of granular soil), suppress dilation of the soil, enhance compaction-induced stresses, increase ductility, and reduce the migration of fines. Consequently, connection of the facial element, reinforcement pullout, and other mechanisms associated with the traditional design model used for MSE are not modes of failure for GRS. In short, the internal stability analysis of GRS differs from that of traditional MSE.

The GRS technology, together with the reinforced soil foundation (RSF), and the integrated bridge approach, formed IBS. IBS has tremendous cost and construction advantages for bridge support applications when the site suits its application. Unlike MSE, particularly true bridge abutments, which have limitations for water crossing applications, IBS, however, suits water crossing applications.

The internal design of GRS-IBS, which is the focus of this presentation, is based on Federal Highway Administration's (FHWA) Design and Construction of Geosynthetic Reinforced Soil (GRS) Abutments and the Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS) Publication No. FHWA-HRT-17-080. The external design requirement of GRS-IBS, particularly for seismic requirements, is still based on the analysis for MSE as specified in the American Association of State Highway and Transportation Officials (AASHTO). Attention is made to address the cyclic water level fluctuation within the abutment and the detailing requirements involved. This is crucial, as at times the neglect of the hydraulic requirement for past MSE applications has resulted in detrimental consequences.

DESIGN OF A NEW TYPE OF STEEL TROUGH RAIL BRIDGE FOR KIWIRAIL

Mr Owais Arshad[1], Mr Ronald Wessel[1], Mr Geoff Brown[1], Mr Jamil Khan[1]
[1]Beca Ltd, [2]KiwiRail

Session 2B, Brooklyn 2, July 8, 2024, 10:30 AM - 12:30 PM

KiwiRail's update and introduction of significantly reduced clearance envelopes for new bridges and the new Rail Bridge Design Annex to the NZ Transport Agency Bridge Manual, provided the opportunity to introduce a new and more compact steel bridge type of superstructure to New Zealand's rail network, to be used in particular for bridge replacements. The replacement of Bridges 45SNL, 88MID, 89 MID, 133SNL and 189MNL showcases this new design.

The superstructure design is based on a design developed by the UK national rail authority Network Rail. It consists of an orthotropic U-shaped trough type deck with a welded transverse flange plate with ribs connected to stiffened webs and flanges. A composite concrete infill slab is provided to the bottom flange of the trough. Ballast and rail track then sit within the steel trough. The concrete and steel faces in contact with the ballast are provided with a spray on waterproof membrane to protect them from corrosion. The design is more compact and significantly lighter than previous steel trough designs used in New Zealand, and hence more economical.

The span lengths for the replacement bridges vary between 15.5m and 22.3m and have been designed and detailed to suit New Zealand loading and design standards and to be fabricated using weathering steel.

The steel trough deck spans are designed to be fully fabricated and welded offsite with spans being transported as a single module and able to be lifted into -place on site, detailed in a manner to enable modular and systematic modifications of the spans to suit varying span lengths. This is a first step for KiwiRail to develop standard steel span designs to cater for a range of spans.

The use of weathering steel enables the omission of any additional external corrosion protection resulting in reduced maintenance throughout its design life.

The presentation discusses the key design aspects, challenges and constraints, such as detailing of this deck type for the use of weathering steel and design aspects not covered by AS/NZS 5100.6.

DESIGN OF ROAD EMBANKMENTS ON SOFT SOIL: INSIGHTS FROM PRACTICE AND RECOMMENDATIONS

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Session 4C, Brooklyn 1, July 8, 2024, 4:00 PM - 5:30 PM

Construction of road embankments on soft soil presents notable challenges such as significant ground settlement, embankment instability, and significant post-construction total and differential settlements. To mitigate this, engineers typically use varied ground improvement techniques and modern technology during the design and construction stages, aiming to secure embankment stability during construction and lessen total and differential settlement post-construction. The effectiveness of these innovative ideas hinges on a good understanding of soft soil behaviour, the ability to accurately predict its performance, and the effective implementation of quality control.

This presentation presents a review of the current practice for the design of ground improvement techniques for road embankments on soft soil in New Zealand and internationally including the requirements in the NZTA Bridge Manual.

As an example of New Zealand practice, an overview is presented on the challenges faced and solutions implemented during the design and construction of the Peka Peka to Ōtaki Expressway on the Kāpiti Coast in Wellington, with a particular focus on managing the presence of soft soil. The soft soil, largely composed of amorphous peat and organic silt, presented geotechnical difficulties due to its low strength, high compressibility, and variable thickness, which is expected to cause significant total and differential settlements. Ground improvement methods such as surcharging and undercutting were employed to circumvent these challenges. Back analysis based on subsurface investigation data, laboratory testing, and field monitoring program enabled confident predictions about settlement magnitude and surcharge duration.

As a conclusion, this presentation will propose a set of recommendations intended to guide future designs of road embankments on soft soils.

DESIGN OF THE NEW BEAUMONT BRIDGE – CROSSING NEW ZEALAND'S LARGEST RIVER

Mr Jeremy Jennings[1]
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Session 2B, Brooklyn 2, July 8, 2024, 10:30 AM - 12:30 PM

The Clutha River / Mata-Au in Central Otago is one of New Zealand's longest, largest and most historic rivers with significant engineering heritage. The new SH8 Beaumont Bridge was designed by WSP to address network capacity and resilience issues associated with the existing 1887 bridge. Built on a curved alignment alongside the existing bridge, the new 190m long, five-span bridge utilises continuous composite steel construction to achieve a highly efficient, resilient and cost-effective design at a site with tight geometric constraints, complex foundation geology and significant flood demands.

The bridge alignment and foundation locations were optimised to exploit prominent rock outcrops in the river which avoided the need for construction in the deep river channels. Whilst very strong, the underlying schist bedrock is heavily jointed with significant bands of weak phyllite. The brittle nature of the bedrock, coupled with the deep, steeply inclined river channels required piles up to 14m deep.

Four continuous 1.5m deep weathering steel girders with composite concrete deck spanning up to 45m provide a slender superstructure which maximises flood conveyance while also minimising the height of the approach embankments. The dry, inland bridge location is ideally suited to the use of weathering steel which avoids the need to maintain a protective coating system in an ecologically, culturally and historically sensitive area.

Demands from the 7100 cumec design flood event dominated the lateral design of the bridge and, to achieve a cost-effective design, the girders can tolerate being partially submerged in the design flood. The bridge was designed for the resulting hydrodynamic demands with concurrent traffic loading, thus avoiding disruption to the transport network in major flood events.

The new Beaumont Bridge is the largest highway infrastructure project in the Clutha District in a generation and continues the rich engineering legacy of the Clutha River / Mata-Au.

DETERMINATION OF VS(30) AND SITE CLASS IN ACCORDANCE WITH TS 1170.5:2024 – A CASE STUDY

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Session 6A, Heaphy 2&3, July 9, 2024, 10:30 AM - 12:30 PM

The recently released draft version of the Technical Specification TS 1170.5:2024 provides a site classification system based on the time averaged shear wave velocity over the upper 30m, VS(30). The TS specifies seven site classes (I to VII) depending on VS(30). Three methods for evaluating shear wave velocity (VS) are provided. The methods distinguish between direct field measurements of VS and those inferred from correlations (such as from CPT). The TS specifies percentage uncertainties depending on the method used, which results in a range of VS(30) values to apply in the determination of the site class. By applying the applicable uncertainties, it is possible for multiple site classes to be assigned.

In this case study, CPT, DMT, downhole seismic, cross-hole seismic and MASW were undertaken in close proximity to provide five independent techniques to evaluate VS. This work was carried out as part of a geotechnical investigation for a road improvement project in South Auckland. The methods for evaluating VS in TS 1170.5 were applied and VS(30) determined for each of the five testing types.

The results showed a range of VS(30) that are generally within a single site class (Class V) but fell over multiple classes (up to four) when the uncertainty percentages outlined in the TS were applied, depending on which of the three methods were used. Established correlations from CPT and DMT to VS performed reasonably well in comparison to measured VS. It is suggested that uncertainty percentages could be relaxed where correlations are shown to be reliable or site specific correlations can be developed. Direct measure cross-hole VS was generally higher than downhole seismic VS. DMT inferred VS compared well with cross-hole, and CPT inferred VS compared well with downhole. This may be a refection of the anisotropy between vertical and horizontal soil properties.

DISPLACEMENT BASED SEISMIC DESIGN, INCLUDING EXTENSIVE LIQUEFACTION, TO THE NZTA BRIDGE MANUAL – TAKITIMU FLYOVER BRIDGE

Mr Daniel Cvitanich[1], Mr Cameron Weir[1]
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Session 6A, Heaphy 2&3, July 9, 2024, 10:30 AM - 12:30 PM

The Takitimu North Link Stage 1 project will provide a new expressway connecting Takitimu Drive (SH29) through to State Highway 2. Takitimu Flyover Bridge will allow traffic travelling along SH29 bound for Tauranga to bypass the new intersection.

Takitimu Flyover Bridge will be a 363m long, 7.4m wide, eleven span structure. Three super-T girders per span will be made integral with reinforced concrete pier crossheads with cast insitu pours. The crossheads will be supported on single 1.2m diameter pier columns and 1.5m diameter reinforced concrete bored piles. The structural form of the bridge is almost completely concrete, to minimize maintenance and inspection requirements.

Ground conditions at the bridge site indicate extensive liquefaction potential during seismic events, resulting in cyclic ground lurch and lateral spreading movements and post liquefaction settlements that needed to be catered for in the design. There is potential liquefaction and cyclic softening under a SLS, DCLS or CALS seismic event. Specific analyses and design were carried out for the SLS, DCLS and CALS level seismic events, in accordance with the NZTA Bridge Manual, due to the expected depth of soil strength and stiffness degradation, and the magnitude of ground displacements, increasing with the seismic event severity.

The displacement based seismic design (DBSD) method was adopted, and capacity design principles were followed to prevent unpredictable structural collapse. The simplified direct displacement based design method presented in the Bridge Manual is not suitable for this relatively complex structure. It assumes elastic abutment responses, treats the structure as an equivalent single degree of freedom structure, and doesn't allow for the disparity between strength and stiffness which can occur with cased piles. Therefore, a modified DBSD method was adopted, following the principles outlined in the NZTA Bridge Manual Commentary, to handle the structures complexities and provide a more economic design solution. As required by the Bridge Manual, cyclic ground movements and slope movements were superimposed with a percentage of structural inertial demand, depending on the stage in the seismic response the movements were anticipated to occur. There is a lack of clarity regarding how this should be implemented, and which scenario slope movements post liquefaction are applicable to, which can have significant implications on design.

This presentation will provide insight into the limitations of the idealised direct displacement based design procedure, the modified DBSD adopted, and discuss the ambiguities and implications regarding the superposition of ground movements with structural inertial demands.

DYNAMIC RESPONSE AND MODELLING OF MONITORED STATE HIGHWAY BRIDGES

Professor Liam Wotherspoon[1], Dr Pavan Chigullapally[2], Mr Shong Wai Lew[3], Dr Anastasiia Plotnikova[4], Dr Lucas Hogan[1], Dr Max Stephens[1]
[1]University Of Auckland, Auckland, [2]AECOM, Auckland, [3]Meinhardt, Auckland, [4]WSP, Auckland

Session 8 & Conference Closing, Heaphy 2&3, July 9, 2024, 3:35 PM - 4:40 PM

This presentation will focus on the dynamic response of monitored bridges in the State Highway network during recent earthquakes and the performance of numerical models for each bridge. These include the Awatere Bridge in Marlborough, the Thorndon Viaduct in Wellington and the Port Hills Road Overpass in Christchurch. The response of each bridge during or following different earthquakes will be discussed, including damage distribution, the effect of repair and the influence of excitation level on modal characteristics. Key insights from soil-foundation-structure-interaction numerical modelling will be presented. Elastic models were developed to capture the modal response characteristics and changes due to the factors discussed above. Models representing the nonlinear behaviour of the structure and foundations were developed to capture the observed damage distribution or the time-series response. The key characteristics influencing this response across the structure and foundation systems were defined through sensitivity analyses. These outcomes provide useful insights that can inform future numerical modelling and the interpretation of monitoring data following future earthquakes.

EASTERN BUSWAY ALLIANCE – DESIGN OF REEVES ROAD FLYOVER

Mr Jim Chen[1]
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Session 2B, Brooklyn 2, July 8, 2024, 10:30 AM - 12:30 PM

The Eastern Busway project will connect Botany, Pakuranga and neighbouring suburbs to the rail network in Panmure with a dedicated busway between Botany and Panmure.

The Reeves Road Flyover will be constructed to provide a direct link between Pakuranga Road and the South Eastern Highway. The Flyover will run above Reeves Road and across Ti Rakau Drive, aiming to alleviate traffic congestion on Ti Rakau Drive and Pakuranga Road. Two general traffic lanes in each direction are provided to connect South Eastern Highway to Pakuranga Road, along with associated intersection improvements to prioritise vehicle movements between the Flyover and Pakuranga Road, connecting seamlessly to the new Reeves Road/Pakuranga Road intersection. Additionally, the Flyover allows for the narrowing of Pakuranga Road, facilitating enhanced pedestrian and cyclist facilities along this stretch.

Below the Flyover on Reeves Road, a new public space will be created, fostering connectivity between Pakuranga Town Centre and the surrounding community. This space will feature recreational facilities to the south-east of the Town Centre.

The Flyover itself comprises a four-lane multi-span continuous bridge with a total length of 587m between abutments. Each span consists of eight super T prestressed concrete beams, 1825mm deep, with a minimum 200mm thick reinforced concrete deck slab. The superstructure is constructed continuous across the piers using reinforced concrete full-depth transverse diaphragms.

Piers consist of reinforced concrete piles and columns that flare at the top to provide support for the deck. The diaphragms are supported on two spherical bearings at the three piers each end of the bridge, while they are cast integrally with the piers at remaining supports. Each abutment features a rectangular reinforced concrete abutment beam supported by reinforced concrete piles. Load transfer mechanisms vary depending on the pier type, with integral piers supporting loads monolithically, while articulated piers and abutments transfer vertical loads to bearings and lateral loads to shear keys. Spherical bearings are provided under each beam at the abutments, allowing free movement in the longitudinal direction and transverse movement is restrained by transverse shear keys on the abutment.

This presentation will cover the evolution of design and the various factors considered during the design phase.

ECO-VIADUCT: INNOVATION AND RESILIENCE FOR THE MANAWATŪ TARARUA HIGHWAY

Mr Jack Manners[1,2]
[1]Aurecon, Auckland, New Zealand, [2]Te Ahu a Turanga Alliance, New Zealand
Session 2A, Heaphy 2&3, July 8, 2024, 10:30 AM - 12:30 PM

Following a major slip in April 2017, SH3 through the Manawatū Gorge was impassable and the road was permanently closed. Te Ahu a Tūranga: Manawatū Tararua Highway is a NZ Transport Agency Waka Kotahi led alliance project that will provide a safe and resilient connection between Ashurst and Woodville as well as increasing capacity on the vital transport route between the east and west of the lower North Island. This presentation focuses on the structural design of BR03 – Eco-Viaduct, which carries the highway over an ecologically and culturally important site while minimising its impact.

To the north of the Manawatū River the re-aligned SH3 navigates through an area of old growth forest, swamp maire and extensive raupō wetlands. Historically the site was an area of mahinga kai (area of harvest) and continues to hold significant cultural value today. To respond to the site-significance, the design was developed to minimise the permanent and construction footprint on the site as well as reducing the need for ongoing maintenance access and activities in the area.

In addition to considering the ecological and cultural constraints, the design had to address the high seismicity (Z=0.41) of the Manawatū region, including the presence of a historic fault line crossing beneath the proposed bridge alignment. The project mandated that the bridge undergo seismic assessment using both displacement-based and force-based design methods, in compliance with minimum requirements (MRs). Thus, this project serves as a case study illustrating the advantages, disadvantages, and differences between these two design approaches.

Through close collaboration with Alliance partners, a suitable bridge form was selected. The seven-span, 305m Eco-Viaduct supports four traffic lanes and a shared use path and is formed through weathering steel I-girders made composite with a reinforced concrete deck. The spans are made fully integral at all piers through a reinforced concrete diaphragm supported on a 1.8m diameter columns and 2.1m diameter bored piles. At abutments the bridge is supported on sliding pot bearings accommodating movements of up to 600mm longitudinally.

This presentation specifically focuses on the design of the substructure elements and details the design challenges faced, as well as the resulting innovations that enabled the overall project objective of a “light-touch” bridge structure that provides resilience to the difficult site conditions to be achieved.

EFFICIENT GROUND INVESTIGATION USING GEOPHYSICAL METHODS IN EMERGENCY AND INFRASTRUCTURE RECOVERY

Mr Cam Wylie[1], Mr Tony Valentine[1], Mr Tom Grace[1], Mr Oliver Gibson[1]
[1]Resource Development Consultants Ltd, Hastings

Session 4C, Brooklyn 1, July 8, 2024, 4:00 PM - 5:30 PM

Geophysical techniques applied during disaster response to Cyclone Gabrielle damage within the Tararua District for rapid road condition risk assessment, investigation targeting and remediation design facilitated fast track option assessment and mitigation.

This is just one example where the efficient use of geophysics combined with large scale geomorphological mapping early in the project evaluation phase served to reduce the time and cost of traditional drilling investigations by targeting problem areas.

Surface geophysics provides a rapid, repeatable overview of geotechnical properties including, ground strength, density, modulus of deformation, Vs30 and groundwater conditions. These parameters are relevant to design and physical evaluation of landslides, mitigation solutions subgrade modulus and seismic site class. Downhole geophysics including accurate measurement of geological structures and identification of geological and geotechnical zones of influence by televiewers, shear wave velocity, density and other techniques drastically improve the value of the drilling.

Critically, downhole logging significantly reduces the need for manual drilling supervision, subjective core logging and processing by capturing digital data within a digital database tailored for geological and geotechnical modelling using modern 3D interpretive software.

This paper provides case studies from recent road related investigations in NZ.

EVOLUTION OF THE NEW ZEALAND GEOTECHNICAL DATABASE (NZGD): FROM REGIONAL RECOVERY TOOL TO A NATIONALLY-SIGNIFICANT DATA ASSET

Dr Kaley Crawford-Flett[1], Mr Kiran Saligame[2]
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Session 2C, Brooklyn 1, July 8, 2024, 10:30 AM - 12:30 PM

The New Zealand Geotechnical Database (NZGD) is recognised among the New Zealand geotechnical community as an invaluable tool to improve efficiency in geotechnical practice. Eleven years after its inception as the regional Canterbury Geotechnical Database, the nationwide NZGD now contains around 183,000 geotechnical records including Cone Penetration Tests (CPTs), hand auger logs, borehole logs, scala penetrometer tests, and laboratory data. The NZGD has served over 12,200 unique users in the science, engineering, government, insurance, and research sectors. To date, over three million files have been downloaded by engineering consultants, researchers, and insurers.

The evolution of the NZGD was mapped over time in terms of user profiles, data type, regional distributions, data use, and upload and download statistics. Data mapping demonstrates the evolution of the NZGD from a post-disaster regional recovery tool to a national 'business-as-usual' database. The NZGD contains approximately 183,000 investigation files, primarily comprising hand auger (36%), CPT (29%), and borehole (15%) data. The Canterbury rebuild period is characterised by an increased prevalence of CPT investigations compared to pre- and post- rebuild periods. Consultants/contractors and researchers are the primary downloaders of NZGD data (56% and 31% of total downloads, respectively). Since 2013, an annual average of 270,000 files have been downloaded from the NZGD per year.

As of 31 December 2023, 12,228 unique users from 62 countries have registered to use the NZGD. Categorisation of user organisations demonstrates that engineering consultants (including contractors) are the primary user of the NZGD; however, universities and researchers are also a key user group. Insurers and government users also feature; however, there is potential for wider benefits realisation in some sectors. Challenges exist in understanding the use of data beyond download actions. Further work is necessary to better understand and promote the end-use benefits of data contained in the NZGD at both regional and national level.

As the current steward of the NZGD, MBIE has recently undertaken a procurement process to appoint a new supplier who will host and develop the NZGD in the coming years. A transition process is currently underway. The new supplier is expected to deliver an updated and improved web interface to NZGD users in late 2024. This presentation describes the historical evolution of the NZGD, the ongoing transition to a new service provider, and key observations that will help unlock the future benefits of the NZGD for the geotechnical community and wider hazard, infrastructure, and planning applications.

FORENSIC INVESTIGATION OF BRIDGE PERFORMANCE DURING CYCLONE GABRIELLE

Dr Jono Watkins[1], Mr Kwan Chin[1], Dr Moustafa Al-Ani[2], Dr Liam Wotherspoon
[1]WSP, [2]NZTA Waka Kotahi, [3]University of Auckland

Session 3B, Brooklyn 2, July 8, 2024, 1:30 PM - 3:30 PM

What attributes of a bridge's configuration are likely to lead to collapse or significant damage during an extreme flood event? Are our design codes and practices appropriate for floods? This paper uses a database of 1500 structures across the East Coast region of the North Island to answer these questions. Data collated for each structure included structural configuration details and damaged experienced during Cyclone Gabrielle.

We expect the results to show that certain bridge configurations are more likely to be damaged during extreme flooding such as - undersized foundations, insufficient hydraulic area, span length, and year constructed. In regard to design codes, we found that the typical substructure flood design loading has increased dramatically over the years. Key inflection points were code revisions in 1976 introducing debris mats and 2013 significantly increasing the drag co-efficient associated with debris mats.

The East Coast bridge stock is reflective of that around Aotearoa New Zealand and was shown to exhibit several key vulnerabilities. Knowing this will better inform new design and strengthening of existing structures. The findings from this study will also inform improved scour screening process.

FRP DECK STRENGTHENING DESIGN AND CONSTRUCTION OBSERVATIONS

Mr Brent England[1], Rebecca Johnson[1]
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Session 3B, Brooklyn 2, July 8, 2024, 1:30 PM - 3:30 PM

Over the last 5 years, Beca has identified a number of bridge deck slabs in poor condition and inadequate capacity for heavy traffic loads across the Waikato and Bay of Plenty state highway network. The deficient bridge deck slabs are typically 6" (152 mm) thick with relatively light reinforcement in each direction, as is common in many of New Zealand's older reinforced concrete bridge deck slabs. Once the slab has significant cracking the Simplified Evaluation Method (SEM), provided in the Bridge Manual for assessing deck slab capacity, has generally revealed that the slab capacity is inadequate.

Strengthening of the bridge decks has involved the application of Fibre Reinforced Polymer (FRP) strips in both directions on the slab soffit. This has increased the slab flexural sagging capacity to be adequate for High-Performance Motor Vehicles (HPMV) vehicle loads and generally achieves a Deck Capacity Factor (DCF) of 1.0 or more. To date sixteen bridges have been strengthened using this technique.

The design of the FRP strengthening has been completed in accordance with the Bridge Manual and the procedures outlined in ACI 440.2R. The design method is based on strain compatibility principals and includes various limit state capacity checks.

The successful application of the FRP relies on adequate preparation of the concrete substrate, which is verified by 'pull-off' testing to confirm the bond strength satisfies the design requirement (1.4 MPa). Several of these projects, which have been strengthened with Sikawrap Hex103C, have been installed under live traffic loading with no detrimental effects or loss of bond being observed. This has minimised disruption to road users and reduced construction time.

The application of FRP to strengthen these bridge decks has significantly extended the service life of these older bridges, providing cost savings and tangible sustainability benefits compared to full or partial bridge replacement options. It results in minimal additional weight and is relatively quick to install which makes it an ideal solution for many bridge strengthening applications.

This presentation will provide an overview of the analysis, design and installation observations on these deck strengthening projects.

GEOSPATIAL MANAGEMENT OF GEOHAZARDS AND GEOTECHNICAL STRUCTURES ACROSS STATE HIGHWAY NETWORK

Miss Danielle Barnhill[1], Mr John Kreft[2]
[1]WSP, Wellington, New Zealand, [2]WSP, Christchurch, New Zealand

Session 6C, Brooklyn 1, July 9, 2024, 10:30 AM - 12:30 PM

The presence of geological hazards, such as discrete rockfall events and large-scale slope failures, is well known and nothing new to Aotearoa. New Zealand's transportation corridors navigate challenging terrain, resulting in infrastructure and users often being subject to geohazards, potentially causing severe economic disruption and risk to life safety.

The 2016 Kaikōura 7.8mW earthquake demonstrated how fragile New Zealand's transportation network is, with arterial transportation routes including State Highway 1 suffering significant damage from seismic induced landslides and rockfall. The North Canterbury Transport Infrastructure Recovery (NCTIR) alliance successfully restored these vital transport links by installing structural mitigation to alleviate continuing geohazard activity.

After the recovery had finished Waka Kotahi NZ Transport Agency (Waka Kotahi) was responsible for maintaining a large inventory of geohazards and geotechnical structures, critical in the provision of a safe and resilient transport corridor, within a post-earthquake environment.

WSP collaborated with Waka Kotahi to develop and deploy a field-proven collector app for Network Outcomes Contract (NOC) operatives to record rockfall and landslide activity during routine state highway inspections. These data along with traffic information and geological slope characteristics are combined to estimate a real-time risk level. Outputs are presented in a suite of ArcGIS Online interactive dashboards, displaying information pertinent to hazards along the state highway network.

WSP further innovated to create a near-real time slope movement forecasting system, using historic data (rockfall and rainfall) to identify thresholds at which geohazards generate an unacceptable level of risk. Pairing this with forecast rainfall data generates a short-term risk prediction and allows the NOC to make rapid informed decisions on mitigation (e.g reduce speed, lane drop, road closure), to reduce the immediate risk to life safety of road users.

This results in an automated, robust and defensible way of assessing the risk of slope movement in near-real time. Ultimately, this system allows Waka Kotahi to proactively manage the evolving risks posed by geohazards to road users, whilst at the same time undertake longer-term resilience assessments to either invest in permanent mitigation or consolidate the current approach (e.g. addition of instrumentation and smart technology).

INNOVATIONS IN DESIGN AND CONSTRUCTION OF THE REPLACEMENT SH1 BRIDGES OVER THE NIMT RAIL LINE

Mr Richard Nutton[1], Mr Sam Lawson[2]
[1]Aurecon, Auckland, New Zealand, [2]Fulton Hogan, Auckland, New Zealand

Session 2B, Brooklyn 2, July 8, 2024, 10:30 AM - 12:30 PM

The SH1 Papakura to Drury upgrade is a NZ Transport Agency Waka Kotahi led project to improve transport capacity, safety, and functionality, allowing for long term growth in the south of Auckland. The project involves widening the motorway from four to six lanes and construction of new bridges and a shared use path, whilst maintaining four lanes of traffic live. This presentation describes the structural design and construction of three bridges over the North Island Main Trunk (NIMT) rail line which replace the existing motorway bridges dating from the mid-1960s.

The replacement bridges carry the SH1 mainline as well as northbound and southbound ramps over the NIMT corridor at the highly constrained Drury Interchange. The replacement bridges are lifted and lengthened, compared to their predecessors, increasing the envelope of the rail corridor allowing for electrification of the lines and unlocking future rail corridor improvements.

Delivering both programme and health and safety benefits, the bridges were successfully delivered prior to electrification of the NIMT lines (Quarter two of 2024). To achieve this important project milestone, the bridges were delivered as an early works component of the project where the bridges were constructed in advance of the approach works.

The 40m single-span bridges are formed through weathering steel U-trough girders made composite with a cast in-situ deck slab supported on a bored pile and reinforced concrete substructure. This form eliminates the requirement for a pier within the rail corridor. This unobstructed rail envelope accommodates the current 2-track requirements with provision to increase to 4-tracks as well as a future shared use path (SUP).

This presentation will cover design and construction innovations delivered through close collaboration with NZTA and key stakeholders that ensured successful delivery against the objectives, including:

- Adopting a unique weathering steel trough girder structural form
- Reduction in temporary works and working from height requirements through the provision of permanent formwork and pre-fabricated utility supports
- Challenges designing and constructing within the rail corridor including designing for rail impact as well as earthing and bonding considerations

The design and delivery of the replacement NIMT bridges at Drury Interchange provide a case study for how close collaboration between the client, stakeholders, designers and constructors can deliver innovation resulting in programme efficiency, risk mitigation working within the rail corridor and ultimately delivering improved outcomes for all.

INVESTIGATION AND DESIGN OF ROCK SOCKETS IN ECBF VOLCANICLASTIC CHANNEL DEPOSITS FOR LARGE DIAMETER PILES IN PAKURANGA, AUCKLAND

Mr Gregory Pinches[1], Ms Stephanie Kirkman[2], Mr Liam Connor[2]
[1]Aecom, Auckland, New Zealand, [2]Jacobs, Auckland, New Zealand

Session 7A, Heaphy 2&3, July 9, 2024, 1:30 PM - 3:30 PM

The Eastern Busway Alliance is designing and constructing the 600m long Ra Hihi Flyover (RHFO) through Auckland's Pakuranga town centre. The reinforced concrete viaduct is built with 35 m long Super Tees supported on sixteen monopole piers each extending up from a 3m diameter bored pile, the largest in New Zealand. Design pile capacity is solely provided by skin friction in rock sockets formed in the East Coast Bays Formation (ECBF).

Investigations showed that the Classic ECBF of interbedded siltstones and sandstones is here accompanied by a volcaniclastic sandstone variant interpreted as being deposited in a higher velocity channel. This Reeves Road Channel Deposit (RRCD) is analogous to what has been described as Parnell Grit at other Auckland locations.

The rock socket design assumed different geotechnical parameters for the volcaniclastic RRCD unit and the Classic ECBF unit. Skin friction for rock socket design was derived from the characteristic UCS strength of each. Understanding of the ground conditions for the RHFO has evolved over multiple phases of geotechnical investigation culminating in a proof boring programme featuring a fully cored drillhole extending 9m below the preliminary design pile toe level at each pier. The proof bores were undertaken to confirm the design rock head levels, rock socket composition and strengths. A key feature was the Uniaxial Compressive Strength (UCS) testing of over 120 rock specimens.

Volcaniclastic sandstone was recognised from the beginning but understanding of its extent, strength and thickness developed throughout the investigations. An outline scheme of five typical lithologies is proposed with the most characteristic being a clast supported conglomerate marker horizon defining the base of the channel. In its upper beds the reduced size and frequency of clasts renders the Channel Deposit similar in appearance to a thick sandstone of the Classic ECBF.

Interrogation of the large UCS dataset allowed refinement of the representative strength for the volcaniclastic RRCD and Classic ECBF over the length of the RHFO structure to provide a more statistically representative skin friction for geographic groups of piles.

This paper provides guidance on recognising volcaniclastic channel deposits and demonstrates that they may be more extensive in the ECBF than commonly considered. A large UCS strength dataset is referenced which clearly differentiates the characteristic strength of the channel deposits from the Classic ECBF. The paper shows how these strength variations can be used to optimise the design of pile socket lengths.

KIWIRAIL BRIDGE 223A PNGL MAKE SAFE CYCLONE RECOVERY

Mr Rudolph Kotze[1]
[1]Holmes NZ LP, Wellington, New Zealand

Session 7B, Brooklyn 2, July 9, 2024, 1:30 PM - 3:30 PM

Cyclone Gabrielle caused widespread damage to road and rail infrastructure on the east coast of New Zealand. The rail link between Napier and Wairoa sustained significant damage, including washouts, slips and damage to civil, track and bridge structures. As part of the recovery stage, KiwiRail established an alliance comprising Holmes, WSP, Aurecon and Tonkin and Taylor to undertake damage and options assessments for repair and/or reinstatement of the assets on the section of the Palmerston North Gisborne Line (PNGL). In parallel, KiwiRail also undertook a "Make Safe" programme to ensure that the post-Cyclone damaged assets were made safe from a health and safety perspective as well as protecting the surrounding areas from similar flooding occurring before reinstatement or repairs could be completed. From a bridge perspective, this programme entailed removal of debris, track, significant damaged components such as piers/spans and also temporarily stabilising bridge supports to protect against further flood events. Bridge 223A, which comprises five spans of steel plate girders, supported on reinforced concrete piers and abutments. The piers were constructed on mudstone on spread footings. The flood which came through the bridge undermined specifically one footing, which was deemed to be at risk of further movement which would cause the pier to become unstable and potentially cause significant damage to the superstructure. Access to the bottom of the riverbed is very restricted and difficult to reach, and in developing solutions for stabilising the pier footing were driven by safety considerations for staff and contractors undertaking the work. Numerous options were considered, also taking into account plant materials to be transported to the riverbed. This presentation will discuss the cyclone damage, option development and eventual solution implemented to stabilise the bridge pier. It will also provide the rationale for the stabilisation system of micro piles selected and considerations for ensuring that the temporary repairs would also become part of a future reinstatement design.

MAINTAINING A SAFE AND TRAFFICABLE STATE HIGHWAY OVER A LARGE SLOW-MOVING LANDSLIDE

Mr Christoph Kraus[1], Miss Sian France[1]
[1]Beca Ltd

Session 3C, Brooklyn 1, July 8, 2024, 1:30 PM - 3:30 PM

In August 2023, cracking across both lanes of State Highway 1 (SH1) was observed near Utiku, south of Taihape. The locations of the mapped cracks coincided with the scarp of the existing Utiku Landslide, a large slow-moving landslide that has intermittently impacted SH1 and the North Island Main Trunk (NIMT) railway line since at least the 1960s. The surface cracking and deformation along SH1 observed in August 2023 resulted from renewed movement of the landslide on the basal failure plane some 55-75m below SH1, caused by elevated groundwater levels due to a sustained period of above average rainfall.

As part of the emergency response, we completed geomorphological mapping of the landslide, installed instrumentation to monitor groundwater levels and landslide movements, put temporary traffic management controls in place, and developed a trigger action and response plan (TARP) to facilitate continued safe use of SH1 by road users.

Subsequent to the initial emergency response an immediate design solution that allowed removal of the traffic management controls before Easter 2024 was developed. The solution involved four key aspects, though not all could be fully implemented prior to Easter: (i) road design including undercut and subgrade improvement, as well as minor road realignment; (ii) installation of fanned inclined drains to relieve groundwater pressure and improve slope stability; (iii) surface water and pavement drainage improvements; (iv) ongoing instrumentation and monitoring.

The physical works for the immediate design solution followed standard consenting processes and timeframes (as opposed to emergency works provisions), which had implications for the staging and implementation of the immediate design solution. Completing remedial works outside of emergency works provisions, as well as the location and nature of the Utiku Landslide, provided some unique understandings and challenges. These include the relationship between rainfall and landslide movement, the size and depth of the landslide, ecological impacts, as well as land access restrictions and effects assessments.

This presentation will cover the geology and history of the Utiku Landslide, the initial emergency response, and details of the immediate design solution. We will conclude by providing an overview of some of the unique understandings and challenges associated with the nature of the Utiku Landslide and the impacts of carrying out remedial works outside of emergency works provisions.

MANAWATŪ TARARUA HIGHWAY – BRIDGE 07 SCOUR FOUNDATIONS USING DEEP SOIL MIXING

Mr Graeme Quickfall[1], Mr Ralf Konrad[2], Thomas Northey[1]
[1]Geostabilization NZ Ltd, PO Box 212, New Zealand, [2]Gaia Engineers Ltd, 5 Carmont Place, New Zealand
Session 2A, Heaphy 2&3, July 8, 2024, 10:30 AM - 12:30 PM

The 11km long Te Ahu a Turanga: Manawatū Tararua Highway project will provide an alternative route over the Ruahine Range to the closed SH3 through the Manawatū Gorge. Bridge 07 is a single span bridge crossing the Mangamania Stream near the Mohaka Fault at the eastern side of the Ruahine Range. The bridge superstructure is supported on MSE (Mechanically Stabilized Earth) abutment walls without deep pile foundations.

Design for the Construction of Bridge 07 foundations required scour protection in high flood events whilst providing seismic resilience. A one in 2,500 year flooding event had the potential to scour the river bed 7m which could compromise the structure. Several options were explored but the final solution that met all the criteria was a continuous concrete barrier created by mixing cement with the existing ground materials. The main reason for adopting the deep soil mixing columns was to avoid working directly in the Stream. The original design was to build a temporary stream diversion, de-fish the stream and cut over, on completion of the stream armouring, de-fish again and reinstate the stream.

The final solution incorporated the use of DSM (Deep Soil Mixing) columns. 513, 10 m long columns were installed to create a 100 metre long continuous secant wall each side of the river channel and with an arrangement of 53 abutting shear walls. DSM construction proved successful in a challenging environmental setting.

The paper aims to present the design aspects and construction experiences.

MBIE WORK PROGRAM UPDATE (STRUCTURAL AND GEOTECHNICAL)

Kiran Saligame[1]
[1]Ministry of Business, Innovation and Employment, Wellington, New Zealand

Session 2C, Brooklyn 1, July 8, 2024, 10:30 AM - 12:30 PM

Kiran Saligame will be giving a high level overview of the various pieces of work that is currently on-going within Building System Performance branch of MBIE. The update encompasses wide ranging topics such as addressing seismic risk for new building design (how is MBIE translating new science information to regulation and compliance), seismic risk existing buildings (considers both earthquake prone and non-earthquake prone buildings), New Zealand Geotechnical Database (NZGD), Standards Development (Timber, Steel and Concrete), Dam Safety Regulations and so on.

MIXED DIGITAL MATURITY IN BRIDGE ASSET MANAGEMENT SYSTEMS – STEEL COATINGS ASSESSMENT CASE STUDY

Mr Raed El Sarraf[1], Mr Ben Baty[1]
[1]WSP, Christchurch

Session 6B, Brooklyn 2, July 9, 2024, 10:30 AM - 12:30 PM

Over the past 5 years, there has been a significant increase in the use of digital solutions into Bridge Asset Management. Ranging from simple data capture phone applications to complex deterioration modelling, digital twins and artificial intelligence/machine learning (AI/ML). When used correctly, these have the potential to significantly increase efficiency and assist inspectors and asset owners in better managing their bridge assets; when used incorrectly asset managers risk saturation with low-quality data, and considerable initial capture and on-going IT maintenance costs.

This presentation will provide a shift in perspective on digital twins through an overview of a digital twin maturity model; discuss the concept of "mixed maturity" in digital asset management systems and where higher-level systems may provide value; and provide examples of where various maturity systems have been implemented successfully to provide value. This includes WSP's own "SteelMOD", a digital tool geared toward assisting inspectors and asset managers in identifying the optimal corrosion and coatings management plan for individual bridges, combining corrosion engineering first principals and digital expertise; that was recently used on both road and rail bridges. Finally, the presentation concludes with lessons learnt when building such novel solutions.

MUSING OF A HIGHWAY GEOTECH

William Gray

Session 3C, Brooklyn 1, July 8, 2024, 1:30 PM - 3:30 PM

Highway geotechnical engineering it seems continues to benefit from smarter ideas and kit for use in investigation, design and construction in response to the demands brought on by extreme weather and seismic events, premium construction materials (notably aggregate and sand) becoming scarce and client expectations for guarantees of resilience in built asset performance.

But have things really changed that much? Computer based design offers technical efficiency whilst using largely unchanged fundamental geotechnical principles presented in guidelines prepared by the New Zealand Ministry of Works and others. Success in construction undoubtedly benefits from the bigger and better equipment but still at its core relies of the skills and wisdom of the operators.

William will use his presentation to show colleagues why he is proud and largely satisfied with his time as a “highway geotech” whilst challenging us all to do better and rise to the very real challenges ahead.

NATIONAL BAILEY BRIDGE SERVICES AND A YEAR IN REVIEW

Mr Nigel Lloyd[2], Mr Tony Mans[1]
[1]WSP NZ Ltd, Hamilton, New Zealand, [2]NZ Transport Agency, Wellington, New Zealand
Session 4B, Brooklyn 2, July 8, 2024, 4:00 PM - 5:30 PM

Bailey bridges are a versatile, modular steel panel bridge, invented by Sir Donald Bailey in the early years of World War II. The bridges were designed to be used as temporary bridging for conveying tanks, ammunitions, supply vehicles and army personnel over otherwise untraversable terrain. First used in December 1941 baileys continue to be put into service today as emergency bridging using components fabricated in the 1940s.

During the war years some 320km of standard Bailey and 64km of floating Bailey was manufactured in the United Kingdom – this included approximately 700,000 Bailey panels. Some of this stock was acquired as ex-army surplus post WWII by the Ministry of Works. It has been in demand throughout New Zealand ever since. Notable examples of its use have included suspension bridges built for the construction of the Clyde Dam and crossing the Wairoa River following Cyclone Bola and current long term multi-span bridges at Raparapaririki, west of Ruatoria and at Franz Josef both which have been in use since the 1990s.

NZ Transport Agency runs two Bailey bridge services contracts, one in the North Island based in Hastings, one in the South Island based in Christchurch. Both contracts are currently held by Downer NZ Ltd. Under normal circumstances NZ Transport Agency holds sufficient stock to have in service 20 no. 30m span Bailey bridges on each island but with the unprecedented weather events of early 2023 this stock level has been truly put to the test.

Cyclone Gabrielle and the preceding Auckland Anniversary Weekend Storm created extensive damage across the eastern side of the North Island. This included the loss of many local authority bridges and two state highway bridges. Several temporary bridge solutions have been utilised during the initial response and recovery phases to these events. This includes the construction of 16 Bailey bridges and one additional modern equivalent by the NZ Transport Agency Bailey bridge service, totalling some 664m of bridging.

This presentation will provide an overview of the Bailey bridging services available to state highway maintenance contractors, local authorities and private enterprise through the NZTA Bailey bridge services contracts and showcase the versatility of Bailey bridging and some of the difficulties encountered on the journey to re-connect the communities throughout the Hawkes Bay and Gisborne areas.

NATIONAL RESILIENCE ASSESSMENT, RISK CONTROL & NETWORK IMPROVEMENTS

Richard Topham[1]
[1]Waka Kotahi NZ Transport Agency, Auckland, New Zealand

Session 2C, Brooklyn 1, July 8, 2024, 10:30 AM - 12:30 PM

Richard will present how Waka Kotahi is assessing natural hazard risk, prioritising the control of risk and developing investment programmes to ensure disruption is minimised on the transport network as well as monitoring the impact of Climate Change.

NAVIGATING CONSTRAINTS: DESIGN OF THE SH1 OTUUWAIROA STREAM TWIN BRIDGES

Mr Jack Manners[1], Mr Dan Sandilands[1]
[1]Aurecon, New Zealand

Session 7B, Brooklyn 2, July 9, 2024, 1:30 PM - 3:30 PM

The SH1 Papakura to Drury upgrade is a NZ Transport Agency Waka Kotahi led project to improve transport capacity, functionality and provide safety improvements, as well as allowing for long term growth in the south of Auckland. The project involves widening the motorway from four to six lanes and construction of new bridges and a shared use path, while keeping the existing four lanes of traffic live. This joint structural and geotechnical presentation describes the design of the twin bridges over the Otuuwairoa Stream (Slippery Creek) which replace the existing bridges built in the mid-1960s.

The road corridor in the Otuuwairoa Stream vicinity is tightly constrained by a site of cultural significance to Mana Whenua (Oopaheke Pā) on both sides. This created a design and construction challenge of how to construct the new bridges while maintaining the current four lanes of traffic which carry more than 80,000 vehicles on an average weekday. To meet flood design requirements the proposed bridges and approach embankments are elevated four to five metres above the existing carriageway.

Through rigorous collaboration with the design team and stakeholders, it was determined that the only practicable means of design and construction was to:

- Shift the new road alignment east as far as possible (less constrained than western side).
- Construct the first two lanes of the southbound bridge and approach embankment, then transfer southbound traffic onto these new temporary lanes.
- Demolish the existing southbound bridge, then construct the remainder of the new southbound bridge using a longitudinal stitch joint and widen the approach embankment.
- Transfer the existing northbound lanes onto the completed southbound bridge, which is designed wide enough to carry four lanes of traffic temporarily.
- Demolish the existing northbound bridge, construct the new northbound bridge and complete the approach embankments. Then transfer traffic back to the northbound bridge.

This presentation covers the site history, including a flood that washed out a section of the existing bridge and observations of significant settlement at the existing embankments. We will discuss both geotechnical constraints and structural innovation that allows for staged construction within a very narrow corridor. Our design and construction staging has been developed to maintain traffic flowing safely through the construction zone by separating live traffic lanes from construction activities. This case study will be a useful reference for practitioners on how to tackle complex construction staging challenges.

NETWORK INFRASTRUCTURE GEOTECHNICAL EMERGENCY RESPONSE TO MULTIPLE OCCURRENCE REGIONAL LANDSLIDE EVENTS (MORLES)

Mr Hunter Jenkinson[1], Mr Andrew Holland[1]
[1]HD Geo, Hamilton, New Zealand

Session 4C, Brooklyn 1, July 8, 2024, 4:00 PM - 5:30 PM

Cyclone Dovi in 2022, the 2023 Auckland Anniversary Storm, and Cyclone Gabrielle caused catastrophic and widespread damage across the upper, central, and eastern areas of the North Island. The impact these Multiple Occurrence Regional Landslide Events (MORLEs) had on the roading networks was immense, with flooding, erosion and thousands of landslides and slope instability features causing damage or completely destroying carriage ways. The geotechnical triage phase of the emergency response for these events was critical for initial risk management but also for providing key stakeholders with justification on where they needed to focus their resources and budget for the rebuild phase.

HD Geo formally inspected and triaged over 330 landslide and slope instability features over a 18 month period covering four different District Councils, with approximately 75% of the sites assessed within 1-2 months of the event occurring. Our approach was a simplified, rapid assessment, providing critical information to our clients and key stakeholders so they could prioritize emergency works to ensure user safety and highlight where optioneering for significant repairs was required. Our approach to the emergency response was commended but it was by no means perfect. What we learnt from the events has highlighted an opportunity for improvements that could be industry-wide to streamline geotechnical emergency responses in the future.

Our presentation will outline our approach to the triaging phase of these events, what went well, what didn't go well, and propose the idea of creating a standardized triaging framework that could be used across the industry. Having a standardized triaging system that provides consistency between geotechnical professionals nationwide would ensure repeatability between consultancies, reduce variability in judgement, and allow asset owners, including NZTA Waka Kotahi to better understand the wider impacts of MORLEs.

There are existing risk assessment tools available for network infrastructure such as the ARL and NZTA RHR methods; however, these methods are proactive and best suited for asset management and are either too time-intensive, or not appropriate in an emergency works response. We propose the idea of a scoring type system that could draw on ideas and methods from the proven ARL method and other landslide and emergency risk assessment frameworks.".

OPPORTUNITIES FOR CARBON EFFICIENCY IN BRIDGE DESIGN

Ms Hanna Davidson[1], Mr Kwan Chin[1]
[1]WSP, Auckland, New Zealand

Session 6B, Brooklyn 2, July 9, 2024, 10:30 AM - 12:30 PM

As bridge engineers, we are designing some of the most carbon-intensive elements of the transport network. We are often using high volumes of concrete and steel to balance challenging design demands with cost and material efficiency. The demands on our structures are unlikely to decrease, so with carbon reduction being a major focus in infrastructure design work, finding efficient ways to design with lower embodied carbon is a priority. This presentation will outline a benchmarking exercise, carrying out life cycle assessments on a sample of New Zealand bridges to record trends in structural forms and present observations that could assist efforts to reduce embodied carbon in bridge design.

The sample comprised 32 bridges, primarily in the Auckland and Waikato regions, with two others in the Central North Island and two in the South Island. Structure types included concrete, steel and steel composite bridges. Total structure lengths ranged from 18 to 305m, with span lengths between 12 to 60m. Life cycle assessments on each structure were conducted covering modules A to D, following the MBIE Whole of Life Embodied Carbon Assessment Technical Methodology Guidance.

The benchmarking results demonstrated lower embodied carbon when using super tee and hollow core beams This presentation explores opportunities for the industry to apply these results to progress sustainable bridge design with the increased use of alternate prestressed concrete beam shapes or composite steel dowel beams.

The potential for improved efficiency in substructure design will also be explored based on the findings. Benchmarking results found arrangements had a significant impact on the embodied carbon, with multiple-column substructures tending to be more carbon-efficient than monopile substructures. Other ways to reduce embodied carbon will be presented, such as optimising the crosshead width in integral bridges, the use of post-tensioning, or accounting for permanent pile casings in design.

The variability in embodied carbon depending on the material origin has also been identified as an area for consideration. Broad guidance on the impacts of location and production process will be presented. For example, sourcing materials from further away can result in lower overall embodied carbon, despite the additional transportation or steel produced at an electric arc furnace mill rather than a basic oxygen furnace mill has substantially lower embodied carbon.

OUT OF SIGHT BUT NOT FORGOTTEN: PROVIDING FOR PERMITTED OVERWEIGHT LOADS ON NZ BRIDGES

Mr Andrew Ball[1], Mr Andrew Dickson[1], Mr Mike Beamish[1]
[1]Beca Ltd

Session 4B, Brooklyn 2, July 8, 2024, 4:00 PM - 5:30 PM

Road Controlling Authorities receive thousands of permit applications each year to exceed legal mass limits, for a range of vehicle types including agricultural vehicles, mobile cranes and heavy load platforms. Many of these vehicle movements occur overnight to avoid traffic disruption.

Current design loadings and bridge stock in general provide an adequate level of service for agricultural vehicles and mobile cranes. The same cannot be said for heavy load platforms (HLP).

With increasing investment in the renewable energy sector, transformers and generators transported on HLP from ports to site are increasingly common. Historically, aged structures governed route feasibility - however more recently new bridges are the critical constraint to these loads.

NZ bridges have for many years been designed for “normal” load effects, to accommodate daily freight activities using conforming vehicles. Design for ‘overload’ (permitted overweights) has been based on a highly simplified load model located in any load lane, apparently intended to represent mobile crane loading.

The overload model has little resemblance to the HLP configuration, and specific design for a HLP located optimally on a new bridge is not carried out. With bridge span lengths trending longer, new infrastructure and asset renewals commonly do not provide the overload service levels previously available on the highway network.

Commonly, the heavy load platform load effects on longer span structures exceed 150% of HO design demands. With transporter configurations commonly exceeding 50m in length, operators have limited options to further spread loads within existing road corridor geometrical constraints. As a result, large loads are at risk of no longer being able to travel on many of New Zealand’s primary freight routes without significant investments in asset strengthening.

Changes are required to future-proof heavy haulage capacity across New Zealand’s transportation network. This is becoming of increasing importance as the energy sector transitions to renewable energy production, with numerous power generation projects on the near time horizon. Changes being considered include:

- Adoption/development of new overload design model, comprising a wider platform located at a nominated crossing position(s) on each bridge.
- Nomination of cascading heavy haulage levels of service targets across the State Highway network, to align the benefits and costs.
- Development of a new overload assessment and permitting model, to enable meaningful rating and optimised permitting of existing structures

This presentation will elaborate on the issues above and include details of solutions being considered to address them.

PARAMETRIC DIGITAL WORKFLOWS FOR BRIDGE ENGINEERING

Mr Jonathan Adams[1]
[1]AECOM NZ, Auckland - Auckland City

Session 6B, Brooklyn 2, July 9, 2024, 10:30 AM - 12:30 PM

This presentation outlines AECOM's utilisation of Grasshopper, a visual scripting plugin for Rhinoceros 3D, to streamline bridge engineering workflows through parameterisation and information sharing. The objective was to develop a fully parametric definition for bridge 3D geometry in Grasshopper, which could then be shared and re-used across various other software applications for the purpose of analysis, design and documentation.

The typical approach involves setting out the bridge geometry relative to a single 3D axis representative of the road, rail or shared-use path corridor, defined by a string of x,y,z coordinates or built up from vertical and horizontal curves. The 3D axis is then divided into spans and subdivided further for super-structure segments as required. For in-situ concrete, precast segmental bridges and in-situ slabs for beam and slab bridges, a parametric super-structure section is then defined, including variations along the bridge axis; this is then applied to the 3D axis to form the 3D geometry. Post tensioning profiles, bridge barriers, and surfacing are similarly parametrically defined. For beam and slab bridges, the beam geometry is set out relative to the in-situ concrete slab and the support planes defined, accounting for skew and super-elevation.

Sub-structure geometry, including pile caps, piles and abutment walls are also defined parametrically and can be set to automatically adjust to ground and geotechnical design surfaces. Geotechnical design surfaces can be defined from levels along the corridor or 3d surfaces imported from geological 3d modelling applications.
The parametric 3D geometry definition is then used to define further inputs and transfer information to other engineering applications. Structural analysis models are defined and transferred using the Midas MCT text format; reinforced concrete design sections are prepared and transferred to Autodesk Bridge using a JSON format; and the 3D model is transferred to Revit with Rhino.Inside.Revit.

By adopting this approach, AECOM has reduced errors, increased adaptability, standardised the design approach, and ultimately achieved efficiencies with respect to design programme and effort.

RECENT DEVELOPMENTS IN THE SEISMIC DESIGN OF BRIDGES IN THE UNITED STATES

Ian Buckle[1], M. Kowalsky[4], M.L. Marsh[3], T.P. Murphy[2]
[1]University of Nevada Reno, [2]Modjeski and Masters, [3]WSP USA, [4]North Carolina State University
Conference Opening, July 8, 2024, 8:30 AM - 10:00 AM

This paper reviews two developments in the seismic design of bridges in the United States, both of which have recently been adopted by the AASHTO Committee on Bridges and Structures. In addition, progress is reviewed on a new initiative to better estimate inelastic displacements in bridges during earthquakes.

The first of the new developments is a set of guidelines for the performance-based seismic design (PBSD) of bridges. In these guidelines, a methodology is developed to implement PBSD using strain-based engineering design parameters (rather than ductility-based parameters) to control the performance and expected damage under a two-level seismic hazard approach. The methodology includes determination of analysis and capacity requirements based on the desired performance, seismic hazard, and attributes of the bridge.

The second development is a major change in the way seismic hazard is characterized for bridge design in the U.S. Previously it was based on set of uniform hazard maps in which the return period of the hazard was the same throughout the country. But the consequence of this approach is a non-uniform likelihood of collapse in the life of the bridge. To address this concern, risk-targeted ground motions have been adopted along with their corresponding design spectra. These involve the integration of the hazard curve for each site with bridge fragility to achieve a target collapse probability of 1.5% in the life of a bridge, taken to be 75 years. Uniform risk in the life of a bridge is therefore the focus of these motions rather than uniform occurrence.

Finally, a fundamental step in displacement-based seismic design is the estimation of displacement demand. Current approaches are based on elastic methods. Often called the 'equal-displacement' rule, it has recently been shown to significantly underestimate displacements for some common bridge configurations. The reason is believed to be the way damping is modeled in the benchmark structures. This recently funded project will investigate the limitations of the 'equal-displacement' rule and perhaps propose an alternative for use in design.

Keywords: bridge seismic design, performance-based design, risk-target ground motions, equal-displacement rule.

RECOMMENDATION OF DESIGN PARAMETERS AND CORRELATION TO CALCULATE THE VERTICAL CAPACITY OF STEEL PILES DERIVED FROM DYNAMIC PILE LOAD TESTING

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Session 7A, Heaphy 2&3, July 9, 2024, 1:30 PM - 3:30 PM

The Waikato Expressway is one of New Zealand Transport Agency's (NZTA) seven Roads of National Significance. Tetra Tech Coffey is part of the City Edge Alliance (CEA) engaged by Waka Kotahi to design and construct the Hamilton Section of the Waikato Expressway project. As part of the project, several bridges were constructed across the streams and local roads to connect the 22 km motorway. Most of the bridges were supported on bottom driven steel tube piles founded into the Walton subgroup layer. The Hamilton Basin can generally be divided into two geological terranes, the Hamilton Hills, and the Lowlands. The material at the pile founding layer consists of non-welded ignimbrite, described as silty sand with minor gravels in the Hamilton hill region and silty sand with interbedded alluvial deposits in the Hamilton lowland region. Several high strain dynamic load tests were carried out at each bridge abutment and pier location to verify the axial vertical capacity of the driven steel piles using the Pile Driving Analyser (PDA) method. The base bearing and shaft friction of the test piles were estimated using multiple sensors installed at the top of the piles. In addition, several deep boreholes were drilled in the vicinity of the abutment and pier locations to study the geology of founding layers during the design stage. It was observed that the founding geological layer of bridge piles at both the Hamilton Hills and Hamilton Lowlands areas are different. The minimum required pile length at both terranes to mobilise the minimum required axial capacity shows significant differences. Commonly, 2 different meth-ods are in use to estimate the pile end bearing and shaft friction, during the design stage, namely the standard pene-tration test (SPT) method and the effective stress method. We studied the correlation of end bearing and shaft friction of piles derived from PDA testing with nearby SPT N values and effective stress estimates. The established correlation for the non-welded ignimbrite shows unique results and the established correlation slightly deviates from a standard correlation used in current industry practice. This presentation presents the recommendation of the founding layer and depth for heavily loaded bridge piles at both terranes to gain maximum axial capacity. It also suggests the most suitable correlations for end bearing and shaft friction of driven piles with effective stress and SPT N for piles founded in the non-welded ignimbrite, Walton subgroup layer.

REHABILITATION OF MANGAOTAMA STREAM BRIDGE: A CASE STUDY IN ADVANCED ENGINEERING TECHNIQUES AND PROJECT MANAGEMENT

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Session 7B, Brooklyn 2, July 9, 2024, 1:30 PM - 3:30 PM

The Mangaotama Stream Bridge, originally constructed in 1961, has been a critical structure on SH39, featuring a lightweight superstructure of castellated steel beams and a six-inch-thick composite reinforced concrete deck. Despite extensive repairs over the last seven years, a 2018 inspection revealed significant structural issues including partial loss of composite action, deck cracking, failing bearings, and broken cross bracing welds. This led to the detour of heavy vehicles, resulting in increased costs, travel time and community dissatisfaction.

An optioneering study concluded that replacing the superstructure was the most feasible solution. This approach preserved the hydraulic performance consistent with the remaining design life of the substructure but also offered a cost-effective, sustainable option with a 15% cost premium over alternative solutions. This premium provided enhanced serviceability, such as a wider carriageway and modern Thrie-beam barriers and extended the lifespan of the bridge by an additional 50 years.

The chosen rehabilitation strategy involved constructing a new superstructure composed of steel girders and a composite concrete deck, prefabricated in two halves off-site in Auckland. This method facilitated a significant reduction in on-site construction time and minimised worker fatigue. Critical to the success of this approach was the accurate as-built data of the existing substructure, obtained using advanced survey techniques including point cloud and total station surveys. These were crucial in developing a precise 3D digital model that ensured compatibility between the old substructure and the new superstructure.

The project leveraged sophisticated 3D modelling to refine reinforcing splice details, identify potential clashes, and aid in the communication of complex structural elements to the construction team. The construction phase was characterised by a meticulously planned schedule, broken down into 15-minute intervals, and visualised through staging plans derived from the 3D model. This level of detail in planning allowed for effective monitoring and quick adaptation to any onsite deviations. Despite a minor setback due to pavement misalignment, the project was completed on schedule with in 14 days, demonstrating the efficacy of our innovative construction techniques and proactive project management.

The Mangaotama Stream Bridge rehabilitation project exemplifies how leveraging cutting-edge technology and detailed project management can revitalise aging infrastructure, ensuring its functionality and safety for future generations while setting new standards in the field of bridge rehabilitation.

REVIEW AND CERTIFICATION OF GEOSYNTHETIC MATERIALS FOR WAKA KOTAHI ROADING PROJECTS

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Session 2C, Brooklyn 1, July 8, 2024, 10:30 AM - 12:30 PM

Geosynthetics have been successfully used in the construction of New Zealand roads and railways for decades. They fulfil all the classic functions of reinforcement, drainage, filtration, separation, soil retention and erosion control, enabling engineers to deliver reliable design solutions that meet New Zealand Building Act, Waka Kotahi / NZ Trasport Agency (NZTA) and KiwiRail requirements. With the increasing emphasis on sustainability for road and railway projects in New Zealand, geosynthetics are not only viable, but also competitive materials in terms of carbon footprint - the amount of carbon dioxide resulting from production, delivery, and use the product through its life cycle, i.e. raw material to finished product, compared to conventional construction materials such as concrete, steel, gravel and graded soil filters. A summary of geosynthetics applications for roading and railway projects is given.

Given that multiple geosynthetic products and systems are currently available in New Zealand and internationally, designers should develop a good understanding of geosynthetic product types, their quality and reliability as well as product-specific design methodologies. Use of poor quality geosynthetic products or deficient design methodologies can lead to partial or total failure of geosynthetic reinforced soil slopes, walls, fill embankments and pavements. Several failures of geosynthetic-reinforced soil systems are discussed. Challenges associated with review, approval and certification of geosynthetics in New Zealand and overseas are described. Details of geosynthetics review and certification procedures in Europe and US are briefly discussed. The NZTA review and certification procedure for geosynthetic reinforcement and geosynthetic systems is based on the Bridge Manual Section 6.8 requirements. A detailed NZTA review and certification framework for geosynthetic reinforcement and geosynthetic-reinforced soil systems has been developed and successfully used in recent years. The certification frameworks ensures that the reviews are carried out in a well-structured manner and only quality geosynthetic products are used on NZ roading projects. Details of NZTA review and certification framework as well as recent examples of review and certification for various geosynthetic materials are discussed. A reference to NZTA webpage summarising the geosynthetics review and certification requirements and listing certified geosynthetic products is given.

ROCKFALL PROTECTION STRUCTURES SH1 KAIKŌURA COASTLINE - PERFORMANCE AND MANAGEMENT SINCE INSTALLATION

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Session 6C, Brooklyn 1, July 9, 2024, 10:30 AM - 12:30 PM

Rockfall protection structures are an engineered system designed to passively or actively reduce the risk posed by geohazards such as rockfall, shallow landslides and debris slides/flows. Types of structures include active mesh, spot bolting, drapes, rockfall and debris flow barriers, bunds, attenuators and a rockfall canopy. Following the Kaikōura Earthquake, November 2016, more than 100 rockfall protection structures were installed along the Kaikōura Coastline section of State Highway 1 from Oaro to Clarence with the purpose of: reducing the life safety risk to road and rail users, preventing or limiting damage to road and rail infrastructure; mitigating disruption and improving resilience to the transport corridor.

WSP is the current Geotechnical Management Consultant (GMC) for South Canterbury, North Canterbury and West Coast regions which includes the Kaikōura Coastline. It is nearing 10 years since the earthquake, and 5 - 6 years since the completion of the majority of these rockfall protection structures and the handover to the GMC for ongoing management. As the GMC, WSP are in a unique position to undertake a review on the performance, discuss any challenges and lessons learnt in the implementation and management of these structures since construction. The review will cover:

- The performance of different structure types post event, and the ongoing post-quake recovery of the geohazards and slopes.
- Management of structure performance in an active coastal environment with significant vegetation growth.
- Management of system boundaries and overlapping structure types and the legacy of temporary structures used in construction.
- Challenges around inspection and debris clearance of different structures, including lessons learnt.
- Tools to assist in the management of the structure maintenance (e.g. event triggered instrumentation and corrosion gauges; debris level indicators) and geohazard risk.

Prior to the Kaikōura Earthquake, only a few rockfall protection structures existed across the State Highway network in Aotearoa (New Zealand). Since 2016 a number of new rockfall protection structures have been and continue to be constructed across the country. The findings and lessons learnt from this review will help NZTA, Consultants and GMCs to plan for the whole of life implications of these structures. Building this knowledge into future optioneering to assist with the selection of the best solution for each site with consideration of the overall life management of these unique structures.

SEISMIC AND PERFORMANCE-BASED DESIGN OF ROCK-SOCKETED PILE FOUNDATIONS FOR A NETWORK ARCH BRIDGE

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Session 6A, Heaphy 2&3, July 9, 2024, 10:30 AM - 12:30 PM

The seismic performance of a new Network Arch Bridge that is designed to convey 50 % of freshwater to the Greater Wellington Region in New Zealand was investigated through Soil-Foundation-Structure Interaction and Performance-Based Design principles and methods, under the Damage Control Limit State and Collision Avoidance Limit State, per the New Zealand Transport Agency Bridge Manual.

The geotechnical models were implemented in the finite difference software FLAC and the behaviour of in-situ rock was simulated, using the Ubiquitous Joint constitutive model for rock mass, and the modified Hoek-Brown constitutive model for the major shear zones as weak planes.

The models used in the design investigated the resilience of the proposed asset under various performance levels, evaluated the seismic hazard, investigated the failure mechanisms, and identified key factors contributing to earthquake-induced ground deformations. Steel reinforced concrete bored piles were designed to provide seismic resilience to both the bridge and the natural slopes below it, and permanent rock anchors were designed to improve slope stability to the natural slopes lying below the bridge's level and the new rock cut slopes. The design outcomes anticipated that the performance of the new bridge and adjacent slopes under the Damage Control Limit State seismic design event is compliance with the Bridge Manual and meets Client's expectations. Some slope mitigation measures are anticipated to fail but are considered acceptable.

During construction, all rock anchors have been tested per the International Organisation for Standardisation 22477-5:2018. The rock anchor test results closely coincided with the geotechnical numerical model results, verifying the design validity.

The geotechnical numerical modelling simulated the structural responses for the piles and rock anchors, under the static and the design seismic loading combinations, and all responses were found within the corresponding structural capacities and acceptable displacements. The design of rock socketed piles and rock anchors were verified during construction via in-situ testing.

SEISMIC DESIGN OF AN XBLOCPLUS® REVETMENT USING MULTI-MODEL APPROACH

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Session 7A, Heaphy 2&3, July 9, 2024, 1:30 PM - 3:30 PM

The Te Ara Tupua project is a major shared path link is being created along the shores of Te Whanganui-a-Tara (Wellington Harbour) to connect Ngā Ūranga and Pito-One. The shared path comprises 4.5 km of coastal edge protection which provide improved resilience to the state highway and rail corridor and a shared (pedestrian/cycling) pathway. The project is being delivered by the Te Ara Tupua Alliance.

Granular reclamation fill will provide a platform for the shared path and other recreational areas along the route. An armoured revetment structure is required to protect the reclamation from wave attack over the structure's design life. When designing and constructing revetments, there is often a drive to reduce the footprint due to space constraints and a limited supply of suitable rock armour materials. Concrete armour units present a potentially more sustainable solution to revetment construction than traditional rock armour. XblocPlus® units have been adopted as the armouring for a major shared path project along the shores of Te Whanganui-a-Tara. These units are constructed from concrete in a specifically designed configuration to interlock and remain stable at steep slope angles while providing enhanced coastal performance.

However, these units have had limited application in seismically active areas. The seismic behaviour of the revetment and the concrete armour units has been assessed to understand the performance during and following earthquake shaking. The expected response of the revetment asset to seismic shaking, particularly the interlocking XblocPlus revetment units, is complex and could not be fully assessed using a single method or model. Therefore, a suite of complementary models was used to gain understanding of the various mechanisms of displacement and the performance of the revetment during and after different design seismic events. The methodology that was followed was crucial in determining whether the units would be a viable alternative. This presentation will aim to discuss the different models used to understand seismic performance and to inform the design.

SH1 MANGAMUKA GORGE SLIP REPAIRS - GROUND ANCHORS

Mr Dave Sharp[1], Mr Andrew Cathcart[1]
[1]Grouting Services, Auckland, New Zealand

The Mangamuka Gorge on SH1 in Northland is a critical piece of the NZ Transport Agency's roading network and extreme weather events in August 2022 forced the closure as multiple slips occurred over a 13km stretch of the mountainous range. The Gorge is essential to keep people moving on the Far North Roading Network and a $100m repair project was awarded in early 2023 to CLL Service & Solutions. The project involved a significant amount of enabling works to facilitate the production works.

Grouting Services played a significant role in providing specialist ground anchoring services as part of the retention works over multiple sites across Slip Repair Project. The works initially involved the installation and destructive testing of proving trial anchors to validate the geotechnical ultimate bond capacity of the local ground.

This was followed by the installation of some 320No high capacity multi-strand double corrosion-permanent ground anchors to actively retain the downslope piles anchored into the underlying mudstone rock formation. All anchors were constructed to achieve a 100year design life. Drilling techniques included conventional rotary wash drilling and rotary percussive drilling with hole diameters ranging from 150mm to 200mm. Anchor lengths varied between 22m and 40m.

The sheer scale of the project, coupled with demanding programme requirements dictated the use of multiple drilling rigs and crews, and, required that the anchoring works proceeded in tandem with numerous other activities which required a high level of co-ordination and project management of multi-disciplinary teams. This required intensive coordination and flexibility between all stakeholders.

This paper will focus on the construction and coordination challenges.

SH23 RAGLAN ROAD - GLENTUI SLUMP EMERGENCY DESIGN BUILD REPAIR

Mr Mat Avery[1], Mr Andy O'Sullivan[2]
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Session 7C, Brooklyn 1, July 9, 2024, 1:30 PM - 3:30 PM

Following Cyclone Gabrielle in early 2023 a large underslip developed on State Highway 23 which necessitated a full road closure of the Highway. In late February GeoStabilization NZ Ltd (GSI) was engaged by Waka Kotahi (NZTA) to provide an emergency response remedial solution under a design and build model.

The initial interpretation of the failure mechanism was a simple translational failure occurring in the sidling fill. However, as the failure continued to evolve, a lateral scarp developed diagonally across the slope below the road. Review of the recently completed geotechnical investigation data presented a slope model that didn't align fully with the evolving site conditions. Further site testing was undertaken, including seismic dilatometers (sDMT), instrumented boreholes and additional CPTu. This identified a blind fault transecting the site resulting in a more complex ground model but one which captured all of the observed movements on site. Given the pressure which Waka Kotahi were under from stakeholders to re-open the road, investigations were undertaken in parallel with the temporary stabilization works, which were later integrated into the final design. The initial design concept consisted of a mechanically stabilised earth (MSE) wall founded on a micropiled foundation. However, due to the blind fault, it was not deemed economic to found the piles in a competent layer so the micropiles were replaced with a more robust foundation of Continuous Flight Auger piles.

Close interaction and support from the geotechnical SME at NZTA Waka Kotahi led to a high level of trust and understanding between the client and contractor/designer. This enabled the fast turnaround of the detailed design, completed in just six weeks following the initial site visit, including extensive additional investigations. The efficient design process coupled with the use of specialist equipment allowed the underslip to be remediated in under seven weeks.

The paper aims to present the design aspects and construction experiences focusing on the rapid response and complex geological conditions.

SH25A TAPARAHI BRIDGE - INNOVATIONS IN BRIDGE DESIGN AND DELIVERY

Mr Liam Edwards[1], Aimee Pene[2]
[1]Beca Ltd, [2]McConnell Dowell, [3]McConnell Dowell/Fulton Hogan JV, [4]Tonkin & Taylor

Session 4A, Heaphy 2&3, July 8, 2024, 4:00 PM - 5:30 PM

State Highway 25A Taparahi slipped in late January 2023 following a storm event. The 120m long, 20m deep slip severed a vital connection between Kopu, Hikuai, and the wider Coromandel region. To quickly reconnect the communities New Zealand Transport Agency Waka Kotahi (NZTA) set a clear milestone to open the highway by March 2024. This led to a combined effort by the joint venture contractors McConnell Dowell and Fulton Hogan with designers Tonkin+Taylor and Beca to bring new thinking in how to design and construct a reliable solution. The objective of the team was to open the road as quickly as possible.

The final solution involved a 124m long by 15m high 3-span steel composite girder bridge. What makes this project truly remarkable is the accelerated timeline - from award to an operational highway in less than 7 months, a task that typically takes up to 24 months.

A DfMA Approach was adopted with an aim of Maximising Offsite Construction: A key approach to this rapid delivery was the focus on adopting a Design for Manufacture and Assembly (DfMA) approach to the design and construction of the bridge. In essence, DfMA aims to maximise off-site works and minimise on-site construction with the objective of gaining benefits in programme, risk reduction, health and safety, environmental impact, and quality. Standardised bridge components were developed with early material decisions to allow for prompt procurement, modular construction, and offsite manufacturing, minimising both time and costs and improving construction safety. An innovative example of this approach was to use a full-thickness precast concrete bridge deck unit system without an in-situ topping, which significantly reduced onsite construction activities, resulting in time savings, improved quality, and improved construction safety with less working at height.

There were several other pivotal initiatives which proved critical in increasing productivity, reliability, and quality on this project as outlined below, which will be covered in the presentation:

- Early Option Selection
- Design Freezes
- Utilising Previous Designs
- Simultaneous Design and Construction
- Use of coordinated 3D Models,
- Robust planning and excellent supply chain relationships,
- Resilient project team with redundancy for all personnel and plant.

This successful project has shown New Zealanders that good infrastructure can be done affordably and quickly.

SH5 UTUHINA STREAM BRIDGE SCOUR PROTECTION: THE CHALLENGES OF DELIVERING SOLUTIONS TO EXTEND THE LIFE OF AGING ASSETS

Mr James Griffiths[1]
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Session 2A, Heaphy 2&3, July 8, 2024, 10:30 AM - 12:30 PM

The Utuhina Stream Bridge comprises two structures (1955 & 1977) and carries four SH5 traffic lanes in urban Rotorua.

In 2014 an erosion hole opened near the road median resulting in an unplanned partial closure of the bridge. The cause was linked to erosion beneath the abutment.

Beca assisted NZTA with development of a pragmatic design for the preferred solution. A contract was to be awarded to Fulton Hogan in late 2022 but in the meantime, an inspection identified further scour, related to leakage from stormwater pipe. It was agreed with NZTA that the design needed to be adapted to address the worsening condition.

The solution included driving sheet piles behind the abutment, to cut off the area's where scour was occurring. The updated design required a deep excavation to near stream level behind the abutment to repair the damaged stormwater pipe and allow sheet piles to be driven below.

This presentation will provide a photographic journey through the project and then focus on sharing information around what worked well and openly discussing the lessons learnt. The following bullet points will be touched on in the presentation.

The project challenges included:

- The condition of the site worsened whilst waiting for a contract to be awarded
- Construction required temporary traffic management over a period of months, or a full road closure for a period of weeks
- The detour routes and surrounding area included many different stakeholders
- Construction programme risks included underground obstructions and the stormwater pipe condition.

What went well:

- A full road closure was accepted by NZTA and supported by the local council, which brought the construction programme down from several months to just 2 – 3 weeks.
- Contingency plans were developed to respond quickly to various challenges on site
- The NZTA comms and engagement plan was top notch, and resulted in the public viewing the resulting 2.5 week closure as 'early completion'
- The final contract value was close to original tender despite the increase in scope.

Lessons learnt:

- Existing structures can be difficult to inspect, leading to risks for the construction stage. Being as thorough as possible in the inspections on this project minimised the risks during construction
- Unknown conditions will still exist, and having contingency plans in place for construction reduces risk
- Undertaking these works under a full road closure was the best outcome for all involved.

SH94 HOMER TUNNEL AVALANCHE SHELTER: PART 1 – GEOTECHNICAL CHALLENGES AND OTHER FACTORS INFLUENCING THE DESIGN

Mr Robert Bond[1], Mrs Maddison Phillips[1]
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Session 2A, Heaphy 2&3, July 8, 2024, 10:30 AM - 12:30 PM

Avalanche risk posed to the state highway network in New Zealand is limited to State Highway 94 in the Fiordland National Park of the South Island. State Highway 94 is the only land connection to the spectacular Milford Sound, a major tourism attraction with around a million visitors each year.

Climate change is also now affecting the Milford Road and is increasing the rate of occurrence of geohazards such as avalanche and rockfall. WSP adopted a Future Ready approach to understanding the demands of the future, to manage increasing risks associated with climate change, to improve resilience and to reduce the life safety risk to road users associated with avalanche and rockfall as part of the design of a new avalanche shelter at the tunnel's eastern portal.

The Eastern Portal of the Homer Tunnel is prone to significant avalanche risks from three monitored avalanche paths, each of which rank as Class 4 or 5 (large or major) on the US Avalanche Scale. Whilst the design of avalanche shelters is well documented globally, the environment and position of the shelter at the Homer Tunnel is somewhat unique.

The location of the shelter in an environmentally sensitive national park drove innovative thinking and in taking a Future Ready approach to aggregate sourcing and use, limiting visual impact and a need to complement the historic significance of the existing tunnel structure whilst accommodating tourism and operational demands.

Drawing on the international expertise of WSP in Europe, USA and Canada as well as close collaboration with our structural engineering and bridge structures team, a bespoke Future Ready approach to the design of a new shelter has been achieved and construction is due to commence in 2023.

This paper explores the range of geotechnical challenges posed to the unique design of the shelter and the innovative approaches adopted to overcome extreme load cases and the increasing risks posed by climate change whilst accommodating shortened construction seasons, avalanche risks and an increasing demand for year round tourist access.

The presentation will discuss the history of the Milford Road and the Homer Tunnel and the assessed design requirements of future trends and how they have impacted the design.

The project is an excellent example of a Future Ready approach with a bespoke innovative design in a challenging environment required to protect the public from an ever increasing occurrence of natural hazards.

SH94 HOMER TUNNEL AVALANCHE SHELTER: PART 2 - STRUCTURAL SOLUTION AND CONSTRUCTION PHASE

Mr Peter Routledge[1]
[1]WSP - Nz, Christchurch, New Zealand

Session 2A, Heaphy 2&3, July 8, 2024, 10:30 AM - 12:30 PM

SH94 provides the only land route to the spectacular tourist destination of Milford Sound, New Zealand. The Homer Tunnel carries the road through the Darran Mountains and was constructed between 1935 and 1953. During construction, three workers were killed in avalanches and as a result, a 146m long reinforced concrete avalanche shelter was constructed in 1940. However, in 1945 an avalanche destroyed 100m of the shelter and a further 10m was destroyed by another avalanche in 1997.

In 2021, only 35m of the shelter remained, which was in poor condition and had proven to be inadequate for both avalanche and rockfall. Waka Kotahi, the New Zealand Transport Agency, commissioned WSP to design a replacement avalanche shelter to protect the highway.

The project was highly complex and the WSP team needed to overcome some massive challenges to deliver it. These included construction in a National Park, at a remote site, located in an avalanche runout zone, in a high risk rockfall area and in a region of New Zealand which receives nearly 7m of rainfall per year. The site is highly seismic and is located just over 20km from the magnitude 8.0 producing Alpine Fault. The avalanche starting zone extends 900m above the road and can produce massive plunging avalanches. The structural form needed to resist enormous loads from the avalanche and cater for significant uncertainty in the size of the loads.

This presentation will discuss the numerous challenges at this site leading to the use of entirely precast concrete construction and accelerated construction techniques, allowing the resilient shelter to be constructed in the highly constrained period outside avalanche season.

This project is also a showcase of precast construction and connections using aesthetic features including vapour-blasted designs and tinted concrete.

SLOPE STABILITY AND RISK MANAGEMENT IN RELATION TO TRANSPORT CORRIDORS: A CASE STUDY OF MAUNGATANIWHA RANGE SLIP REPAIRS ON SH1

Mr Shaun Grieve[1], Mr Dwayne Claassen[1], Mr Matt Leggett[1], Ms Kathleen McMullen[1]
[1]WSP, , New Zealand

Session 7C, Brooklyn 1, July 9, 2024, 1:30 PM - 3:30 PM

This presentation discusses a case study on slope stability and risk management in relation to transport corridors, focusing on the Maungataniwha Range slip repairs on SH1. The study addresses the challenges encountered in a geologically complex region, designated as an Outstanding Natural Landscape (ONL), and highlights the collaborative and innovative approaches taken to understand and mitigate slope failures within this environmentally significant context.

The Maungataniwha Range, known for its intricate geological formations, experienced significant slope failures due to heavy rainfall, since August 2022, disrupting the transport corridor. Adding to the complexity, the area is designated as an ONL, which underscores its environmental significance and imposes additional considerations on the repair project. To address these challenges, a collaborative approach was adopted, involving geotechnical engineers, environmental experts, local authorities, and mana whenua (the local Māori iwi). The collaboration fostered a deeper understanding of the cultural and environmental significance of the area and informed the decision-making process.

The case study showcases the innovative use of live monitoring systems during the Maungataniwha Range slip repairs. The implementation of live monitoring allowed real-time data collection, enabling adaptive decision-making and proactive risk management. The continuous monitoring of slope behaviour facilitated the early detection of signs of instability, ensuring the safety and stability of the transport corridor.

Comprehensive site investigations, including geotechnical surveys and live monitoring installations, were conducted to assess the changing physical environment. The dynamic nature of the region required the project team to constantly adapt their remedial strategies to effectively mitigate slope failures. The collaborative efforts with mana whenua, combined with the adaptive approach, resulted in successful slope repairs and enhanced resilience of the transport corridor.

The findings from this case study contribute to the advancement of geotechnical engineering practices in complex geological regions, particularly within areas designated as Outstanding Natural Landscapes. The collaborative and innovative approaches employed, including engagement with mana whenua, highlight the significance of interdisciplinary cooperation, environmental considerations, and the implementation of live monitoring systems in slope stability and risk management.

TAKAKA HILL 5 SITES REMEDIATION - CYCLONE GITA RECOVERY

Mr Harris Bindon[1]
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Session 7C, Brooklyn 1, July 9, 2024, 1:30 PM - 3:30 PM

During Ex-Cyclone Gita in February 2018 heavy rainfall affected the Tasman region with significant damage caused to a section of SH60 on the eastern side of Takaka Hill. Damage to this section of SH60 included multiple under and over slips with five sites suffering significant damage and considered 'major' sites (Site 6, 7, 9, 11 and 13). The damage at the five 'major' sites generally comprised large underslips caused by debris flows and scour which reduced the road to a single lane. SH60 is unique because there is no alternative route over the Takaka Hill into Golden Bay, meaning the communities on both side of the hill were impacted and the highway needed to remain open throughout construction.

Beca was tasked with designing a solution that would reinstate the two-lane carriageway to a similar standard to that existing prior to Cyclone Gita. Given the scale of the underslips mechanically stabilised earth (MSE) retaining walls were the preferred solution for each of the 5 sites. These walls were significant in size, up to 40m long and up to 9m high in places (with additional height buried) with large culverts needing to cross through the walls at four of the sites. Each site had its unique challenges including tight space constraints with steep slopes above and below the road, significant colluvium / debris flow deposits, future debris flow risk and large culvert penetrations. These challenges meant that some unique solutions needed to be developed such as reshaping the road and adopting facing solutions on the walls that would provide protection against future debris flow events. Flexibility in foundation depth was included in the design to allow for the presence of deeper than expected colluvium. Our presentation will showcase the design philosophy, how some of these challenges were overcome and lessons learnt in the design space.

The construction of these large MSE walls also held its challenges given the environment and access constraints. These included the sites having tight construction space, temporary works required to secure and maintain a single lane for traffic (designed by others), significant cut heights/excavations to construct the walls in wet gullies, interaction of angled culvert penetration with geogrid layers and weather events during construction. We will also touch on aspects of construction and lessons learnt during the presentation.

TAR BARREL TUNNEL BYPASS – KIWIRAIL MNL RESILIENCE PROJECT

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Session 3A, Heaphy 2&3, July 8, 2024, 1:30 PM - 3:30 PM

The Tar Barrel Tunnel Bypass project is a rail bypass of Tunnel 21 which is the 21st tunnel on the Main North Line (MNL) between Christchurch and Picton. It is positioned between Ward and the Ure (or Waima) River, approximately 45 minutes south of Blenheim. Spanning 167 meters through a fractured mudstone rock formation adjacent to the London Hill Fault.

The tunnel's condition has deteriorated over time and its condition worsened following the seismic activity from the Seddon and Kaikōura earthquakes. To enhance the long-term resilience of the MNL optimising line speed, travel time, and operational costs the decision was made to decommission Tunnel 21 and redirect the railway through a hill beneath State Highway 1 (SH1) south of the existing tunnel (the Tar Barrel Tunnel Bypass project).

The Tar Barrel Tunnel Bypass project involved a rail realignment spanning 1500 meters and a road realignment covering 700 meters, requiring the excavation and transportation of approximately 400,000 cubic meters of mudstone to nearby fill sites, resulting in cut slopes reaching heights of up to 35 meters. Additionally, a new 100-meter-long rail underpass structure and associated retaining walls were constructed to traverse beneath SH1.

The project encountered various challenges, including seismic risks, slope stability issues stemming from the fractured mudstone, the presence of organic materials, anticipated settlement concerns around the proposed rail underpass and SH1 embankments, constraints of carrying out construction adjacent to and between active road and rail routes, and operational restrictions resulting from Covid lockdown.

The presentation will delve into the intricate details of this resilience improvement project, shedding light on the geotechnical challenges encountered, and the innovative design solutions developed to overcome them.

TE ARA O TE ATA: MT MESSENGER BYPASS - CABLEWAY DESIGN & CONSTRUCTION

Mr Danny Beasant[1]
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Session 3A, Heaphy 2&3, July 8, 2024, 1:30 PM - 3:30 PM

Mount Messenger is a remote area 50 km north-east of New Plymouth in Taranaki, NZ. The existing section of State Highway (SH3) in Mount Messenger is steep, narrow and winding. The Te Ara o Te Ata: Mt Messenger Bypass project provides a new 6 km upgrade improving safety and resilience. A temporary cableway was required to provide early access for critical path construction activities. The cableway is a first of its kind for a New Zealand roading project. This was a significant engineering feat due to the challenging ground conditions, heli-access constraints, constrained programme, complex procurement, and cableway anchor demands in the order of 4.5 MN. The geotechnical design and construction required investigations and input from many stakeholders. Notably, large ground anchors in weak argillaceous rocks required careful exploration to ensure a safe and rational anchor design. One tool that was deployed to increase the capacity of the anchors was underreaming, locally increasing the diameter of the anchor fixed length. This presentation summarises the geotechnical design of cableway, the investigations and solutions adopted for the cableway and anchors which are currently in service with DSI Smart sensors installed. The work undertaken is expected to be of interest to those considering construction of a cableway or more generally, anchor practitioners working in similar 'papa' lithologies, or equivalent Late-Miocene soft rocks in New Zealand and internationally.

TE ARA TUPUA – CHALLENGES IN THE DESIGN OF A NEAR-SHORE BRIDGE: A CASE STUDY OF COLLABORATIVE DESIGN

Mr Luke Storie[1], Mr Liam Hall[2], Mr Mikias Yohannes[1]
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Session 3A, Heaphy 2&3, July 8, 2024, 1:30 PM - 3:30 PM

The Ngā Ūranga ki Pito-One section of the Te Ara Tupua project runs along Te Whanganui-a-Tara (Wellington Harbour) and comprises 4.5 km of coastal edge protection and a shared (pedestrian/cycling) pathway. At the southern-most end of the project at Ngā Ūranga, a 211 m long shared path bridge has been designed to traverse across the electrified rail corridor and onto the new path along the coastal edge. The bridge's steel-concrete composite superstructure creates a 5.3 m effective path width which is supported by six piers of varying heights with large diameter (1.8 to 2.4 m) reinforced concrete mono piles.

The location of the bridge at the harbour edge and in the highly seismic region of Wellington, presented challenges for the design from both geotechnical and structural perspectives. At the site, thick, dense reclamation fill overlies marine sediments, both of which are susceptible to liquefaction to varying extents in a design seismic event and result in significant lateral spreading ground displacements toward the harbour edge. This imposes very high lateral loads on the bridge's pile foundations. The bridge was designed for two different areas of representative ground conditions, with half the bridge set back from the harbour edge on one side of the railway line and the other half immediately adjacent to the harbour edge. Furthermore, the bedrock at the site which is comprised of fault disturbed sandstone greywacke and argillite, presented challenges for the pile foundation design in terms of a sharp transition into rock of spatially variable strength, with very high peak shear forces.

The designer's conventional desire to permit pile hinging at ultimate or greater limit states to achieve an efficient design is not possible for all bridge piles at this site. For the seaward section, the piles are subjected to unbounded lateral spreading displacements and hinging of these piles could result in unsatisfactory performance. This presented a particular challenge for the designers to maintain affordability and constructability of the bridge piles. For the landward section, the lateral spreading displacements were much less and so pile hinging could be acceptable in this zone.

Designing the Te Ara Tupua shared path bridge required a collaborative strategy to address these and other challenges. Close collaboration between structural and geotechnical engineers allowed the team to identify crucial loading scenarios, select effective assessment tools, and streamline the design process and soil-structure interaction considerations, which ultimately resulted in substantial cost savings.

TE HONOHONO KI TAI – MATAKANA LINK ROAD BRIDGE & GEOTECH – DESIGN AND CONSTRUCTION

Ms Ella Matuschka[1], Ms Annaliese Boot[1]
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Session 7A, Heaphy 2&3, July 9, 2024, 1:30 PM - 3:30 PM

The new Te Honohono ki Tai Road connects existing SH1 (to the west) and Matakana Road (to the east), just north of the Warkworth town centre. The new road ties into the end of the new Ara Tūhono – Pūhoi to Warkworth (P2Wk) project, to provide additional resilience to the local transport network and cater for the future urban growth expected in the area.

The new road includes a 72m-long, 3-span curved bridge, which carries vehicles and active modes across an existing stream. The bridge consists of precast, prestressed Super Tee girders with an insitu reinforced concrete deck supported on reinforced concrete substructure elements, including piled foundations. The superstructure is integral at the piers, with elastomeric bearings and expansion joints provided at the abutments.

The subsoil conditions at the bridge location are variable, consisting of alluvial, Northland Allochthon and Pakiri Formation soils overlaying Pakiri Formation rock at varying depths. Key geotechnical considerations for the project included:

- Ground strengthening of an active landslide to support the new road through a grid of fibre reinforced concrete continuous flight auger (CFA) piles, and
- Installation of 3 wetland ponds and a network of subsurface drains.

Construction commenced in 2020, and the new road opened in June 2023 (in parallel with the new P2Wk motorway).

This presentation will cover the primary design considerations and construction challenges associated with the new Te Honohono ki Tai Road bridge.

TEMPORARY WORKS MANAGEMENT IN BRIDGE CONSTRUCTION

Natasha Jokhan[1], **Dale McElhinney**[1], **Mandeep Singh**[1]
[1]Brian Perry Civil, Hamilton , New Zealand

Session 4A, Heaphy 2&3, July 8, 2024, 4:00 PM - 5:30 PM

Effective temporary works management is vital for safe and efficient construction. With the introduction of the Temporary Works Procedural Control Good Practice Guidelines in 2019 the construction industry has put into practice key principals of procedural control.
In this presentation we use the construction of two bridges to illustrate the evolution of temporary works management and the benefits of well thought out temporary works with respect to bridge construction. The first bridge we discuss was completed in 2019. It was a 4-span bridge with total length of 120m. Each span has 6 hollow core Super T beams sitting on crossheads with 3 x reinforced concrete piles. This bridge was constructed over the North Island Main Trunk Railway (NIMTR) on private land for the Ports of Auckland’s in land Freight Hub in Horotiu, Hamilton. The other bridge was constructed in 2023-2024 for Quayside Properties Limited over a section of State Highway 2 in Papamoa. The State Highway 2 Bridge was for the most part constructed over live traffic. This bridge was a single span 33m long, constructed with 8 Super T beams with 4 reinforced piled abutments.
We also look at the construction of two retaining structures to illustrate the industries current focus on the consequence of failure when assessing temporary works and construction risk. The first retaining structure was constructed between 2019-2020 to reinstate State Highway 35, near Te Kaha, after a slip affected the carriageway. The second retaining structure was constructed between 2023-2024 to reinstate State Highway 25, near Wharekaho. Both retaining structures were built under lane closures with public access maintained.

By delving into the ongoing development of risk-based temporary works management for bridges and retaining structures, this presentation equips bridge, geotechnical and construction professionals with valuable learnings for future projects, fostering continuous improvement in the field.

THE ADVANCEMENT OF ROCK FALL PROTECTION MEASURES IN NEW ZEALAND

Mr Eric Ewe[1]
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Session 6C, Brooklyn 1, July 9, 2024, 10:30 AM - 12:30 PM

Rockfall poses a significant hazard to infrastructure, transportation networks, and human life in hilly terrains, including New Zealand. Over the years, New Zealand has made significant development and implementation of rockfall protection measures to mitigate these risks. One important milestone was after the Canterbury earthquake in 2011 when the scale of the issues had initiated the use of more sophisticated and advance protection measures, often away from the rock source zone. This also leads to the publication of MBIE's rockfall passive rockfall protection structures design considerations document in 2016. Additionally, the Kaikoura earthquake in 2016 saw an unprecedented scale of rockfall related issues at multiple sites along the coastal network of rail and road. More of these advance design approaches including passive protection structures have been successfully designed and implemented. Following the events, NZTA published 2 documents in 2023 to compliment the MBIE's with a specific focus on roading network considerations on design approach and maintenance guidance on rockfall protection structures. This abstract provides an overview of the evolution of rockfall protection strategies in New Zealand, highlighting key advancements in technology, risk assessment tools, passive protection systems and regulatory frameworks. Beginning with traditional approaches controlling the rockfall issue at source such as scaling, drapery mesh and anchored mesh, this paper discusses the progression towards the passive protection structures as an effective option in addition to traditional approaches. Furthermore, it highlights the importance of collective knowledge and experiences draw from local practitioners, industry system suppliers, governmental bodies as well as drawing on decades of overseas partners expertise and experiences.

THE EVALUATION OF 2D AND 3D ROCKFALL MODELLING FOR LOOP 2, SH94, MILFORD ROAD

Dr Latasha Templeton[1], Mr Hans-Peter Anderston[2], Mr Tim McMorran[1]
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Session 6C, Brooklyn 1, July 9, 2024, 10:30 AM - 12:30 PM

SH94 has been affected by historical rockfall on both sides of Homer Saddle. During site inspections WSP and MRA have identified potential rockfall source areas, rockfall impacts and inferred rockfall debris deposits. The specific focus of this assessment is Loop 2, a location that includes a viewing carpark, identified as having a significant potential rockfall risk. Loop 2 is ~300 m west of the western portal of Homer Tunnel. The assessment of rockfall risk to road users at Loop 2 used several progressively more sophisticated approaches to characterise rockfall trajectories and illustrates the benefit of using high quality topographic models and 3D trajectory modelling to improve estimation of rockfall risk.

Our first approach was to collect numerous oblique aerial photographs and develop a photogrammetric model to illustrate the slope configuration above the Homer Tunnel portals. The aim was to identify potential rockfall source areas that could impact SH94 and eliminate areas that were benign. This model suffered from being unwieldy and having insufficient detail to achieve the objective given the large scale of the site.

Between 2018-2019, WSP utilized publicly available 8 m DEM and determined the likely pathways for rockfall from numerous source areas. We were able to correlate known rockfall events to determine the most appropriate modelling parameters. A 3D Rapid Mass Movement Simulation (RAMMS) model and several 2D Rocfall models were created using the DEM. From preliminary modelling it was estimated that <0.1% of boulder trajectories would reach Loop 2. However, it was recognized that this modelling was developed from a relatively coarse topographic model that limited precision. Following the ALARP principle MRA built an earth bund along the southern margin of the car park to still allow public use of the carpark, but to separate people as much as practicable from the rockfall
hazard.

In 2022 after two rockfall events reached Loop 2, MRA prepared a high-resolution LiDAR based DEM that could be used to update the modelling. Given the more precise topographical representation of the DEM the updated modelling is believed to more accurately estimate rockfall runout, bounce characteristics and kinetic energy. The updated rockfall modelling estimated that 1-4% of rockfall trajectories could reach Loop 2, at least an order of magnitude higher than the preliminary modelling. We infer that small volume rockfalls (flyrock) dominates the hazard despite the potential for larger events. The observations and modelling results justify onstruction of additional rockfall mitigation measures.

THE IMPORTANCE OF GEOMORPHOLOGY WHEN DEVELOPING COMPLEX GROUND MODELS – AN EXAMPLE FROM THE O’MAHURANGI PENLINK PROJECT

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Session 3C, Brooklyn 1, July 8, 2024, 1:30 PM - 3:30 PM

The Northland Allochthon is a unit which has been placed “on its head”; whereby older rocks are often on top of younger rocks, the traditional way that site investigations are undertaken within the Allochthon should also be placed on their head. A sound understanding of the geomorphology is of critical importance when attempting to understand complex geological terranes such as the Allochthon. Once the ground model has been accuracy determined with the help of intrusive investigations, geomorphology can often be a far more insightful tool than systematically located boreholes.

Site investigations within the Northland Allochthon (Allochthon) require a focus on the identification and understanding of different geological terranes within the Allochthon and within the adjacent units affected by its emplacement. Understanding the varied geomorphic terranes is critical when planning and undertaking investigations, as geomorphology enables identification of these geological terranes. The initial investigation stages should focus on identifying the geomorphology and then understanding the geology within each terrane. Intrusive investigations should be considered as a key tool in unlocking the information that the landforms expressions (geomorphology) are presenting.

Many landforms within the Allochthon are very subtle, and traditional methods of assessing geomorphology are limited in the subdued terranes. Digital Terrane Models (DTM) enable the assessment of these very subtle landforms, and the accurate identification of adverse geomorphological and geological features.

The O’Mahurangi Penlink project between Redvale and Whangaparaoa involves significant earthworks through the toe of the southern-most block of Allochthon . This has enabled insight into the materials and the adjacent material affected by the Allochthon. Geomorphology assessment using (freely available) LiADR data enabled the accurate assessment of geomorphic terranes including shear zones or faults between rafted blocks, landslides in the Allochthon, and extent and depth of block slides along bedding plane shears with the adjacent East Coast Bays Formation (ECBF). The extent of the Allochthon is demarcated by a transition zone to Waitemata Group basin sediments characterised by soft sediment deformation. These materials display very different geomorphic expression to the adjacent “typical” Allochthon” and the ECBF materials. Thereby enabling accurate mapping of the geological and geotechnical units along the project.

The East Coast Bays Formation (ECBF) adjacent to the Allochthon is characterised by bedding plane shears which result in shallow block slides when weathered. Assessment of the depth of bedding plane shears and landslide depths is able to be accurately assessed by the geomorphology.

THE PŪHOI TO WARKWORTH JOURNEY

Mr Ted Polley[1], Mr Ash Smith[1]
[1]Beca Ltd, [2]NZ Transport Agency, [3]NX2 Northern Express Group

Session 6B, Brooklyn 2, July 9, 2024, 10:30 AM - 12:30 PM

The Ara Tūhono Pūhoi to Warkworth Motorway project (P2Wk) is an 18.5km extension to the four-lane northern motorway (SH1) from the Johnstones Hill Tunnels to north of Warkworth.
The Northern Express Group (NX2) is undertaking the P2Wk project under a PPP arrangement with the NZ Transport Agency Waka Kotahi (NZTA). The Design and Construct (D&C) portion of the PPP Contract had construction carried out by NX2's Construction Joint Venture team (CJV) comprising Acciona Infrastructure and Fletcher Construction. The design was prepared by NX2's Design Joint Venture (DJV), comprising Beca and Tonkin + Taylor.

This submission describes features considered critical to success for four major bridges on this project.

The location and form of the Kauri Eco Viaduct was considered one of the priority structures for this project. Using an integrated D&C team approach, considering the Kauri forest environmental, ecological and cultural issues, the team produced a bridge form which minimised the impacts to the Kauri forest. Using a detailed field survey of the Kauri and important native trees, and incorporating a curved bridge alignment minimised the effects on the Kauri.

The preferred visual solution for the two 300m plus long curved viaducts was a four-steel girder form. This was preferred to the steel ladder solution traditionally used in New Zealand for medium span structures. Our aim was to provide a superior solution when compared to the Urban and Landscape Design Framework (ULDF) requirements. The steel girder deck form provided a 3m wide deck cantilever which enhances the visual appearance of the bridge and leaves a clean girder web with no external stiffeners visible except at the piers. Temporarily supporting this large cantilever during construction, while 20m high in the air, presented a challenge and CJV's innovative use of temporary welded trusses cast into the precast deck panels as temporary supports permitted the panels to be installed with limited working at height requirements.

ULDF and aesthetic considerations helped determine the form of the Moir Hill Road Bridge design. A more economical, but much less visually pleasing, solution would have been to use two short spans with a tall central pier. The team's solution was a single 50m span steel girder located approximately 25m above the motorway.

The girder bottom flange curves, resulting in a girder depth doubling at the abutment ends, providing a pleasing arch shape which is highly visible by the motorway users below.

THE RISE OF GEOTECHNICAL ENGINEERING IN NEW ZEALAND

Rodney Hutchison

Session 5B, Brooklyn 1, July 9, 2024, 9:00 AM - 10:00 AM

The discipline of geotechnical engineering has come a long way in New Zealand in the past 50 to 60 years. It has risen from barely recognised to a well-respected and highly valued mainstream discipline. But how did it get there?

There are many reasons and drivers, the obvious being education. However, it is easy to forget that other influences have come into play. Of these, the presentation will discuss:-

- The use of advanced technology and analytical power as well as constraints to its effectiveness.
- The effects of adversity and natural disasters which have accelerated and broadened the development of the discipline.
- Our unparalleled access to public/open-source data.

While geotechnical professionals have shown themselves to be responsive and resourceful, it is not all perfect; there are still areas that need to be addressed and there will always be room for improvement and development. On balance, the discipline is in very good health. It is held high in public perception and is seen as adding value to the construction process. Geotechnical professionals should take pride in how they have achieved a valued place in New Zealand's ongoing development.

THE ROLE OF PRAGMATIC DESIGNS AND CONTRACTOR-LED SOLUTIONS IN EMERGENCY RESPONSE – SHARING EXPERIENCES FROM THE BAY OF PLENTY

Mr Pedro Martins[1]
[1]Beca Ltd, [2]NZ Transport Agency, [3]Higgins

Session 7C, Brooklyn 1, July 9, 2024, 1:30 PM - 3:30 PM

Since establishment of the Bay of Plenty East Network Outcomes Contract (BOPE NOC) in 2014, a number of extreme weather events have impacted the region, causing extensive damage to the State Highway network. The presentation associated to this abstract is intended to share emergency response experiences from the region, covering both the response and recovery phases, but with particular focus on pragmatic designs and contractor-led solutions for recovery.

Using a series of local BOPE NOC examples, we discuss how through early identification of risk and a robust optioneering process, these pragmatic, fit-for-purpose solutions can play a key role in the recovery process. Typical advantages of such solutions are their affordability and value-for-money, as well as their accelerated delivery programme.

Specific sites covered include: (i) SH5 RP67-7.63 Ngāhewa stream underslip; (ii) SH30 RP187-3.61 Rotomā underslips; (iii) SH30 RP120-3.26 BSN1232 Taahunaatara Stream Bridge scour; (iv) SH5 RP77-5.10 Waiotapu underslip; (v) SH36 RP28-10.00 Alpaca Farm underslip; (vi) SH30 RP00-2.59 Mourea underslip.

The examples presented cover a range of different technical solutions, including rockfill buttresses, sheet pilling, internal erosion control measures and stormwater management measures. Each of the sites and their respective solutions are discussed in more detail in the presentation.

Resource Management Act (RMA) and planning considerations are also discussed, with particular focus on early identification of: (i) "easy-wins" through permitted activities, therefore not requiring resource consent; (ii) sites which may present an opportunity to use the Emergency Works provision of the RMA (Section 330), but identifying (and avoiding) early in the optioneering process solutions that would be particularly challenging to obtain a retrospective resource consent.

THE WAIROA RIVER BRIDGE: A VALUE FOR MONEY STORY

Ms Safia Moniz[1], Mr Lars Schmidt[2]
[1]Holmes NZ LP, Christchurch, New Zealand, [2]Holmes NZ LP, Wellington, New Zealand
Session 2B, Brooklyn 2, July 8, 2024, 10:30 AM - 12:30 PM

This case study discusses the outcome when Designers are given the opportunity to use innovative and state-of-the-art analytical tools and philosophies in the design of major infrastructure in New Zealand. If we, as infrastructure designers, don’t make the most of current research and best practice, we could lose out on the chance to optimise our resources at a time when every dollar counts. This case study describes how the authors made use of state-of-the-art geotechnical tools and philosophies, which lead to a savings of over $5 Million NZD on a major transport project.

Currently in construction, the Wairoa River Bridge is a 10 span, approximately 350m long bridge. The bridge carries the Takitimu North Link expressway and a Shared Path across Wairoa River and the flood plain and is being constructed by the Fulton Hogan / HEB Joint Venture under a design and construct procurement model. The superstructure consists of precast concrete I girders, integral at the piers, and simply supported at the abutments. The bridge is supported on driven steel tube piles and reinforced concrete columns as well as on large diameter bored concrete piles and columns at the river piers. Most challenging was the lateral demand on the abutment piles considering a 7.5m high approach embankment on deep soft ground.

Ground conditions at the Wairoa River Bridge are complex, consisting of soft alluvium swamp deposits, liquefiable sands to >35m, volcanic soils and rock. For the liquefaction analyses the authors’ methodology included a 1-D Site Response Analysis with pore water pressure generation, to capture the recently published concept of ‘system response’ for liquefaction assessment of a layered soil system. For the seismic slope movements, ground displacements for pile design were estimated using a displacement-based approach. Strength gain in the soils from consolidation by surcharge was considered. These analyses were carried out using Non-Linear Time History Finite Element Analyses with spectrum compatible design ground motions applied to the base of the model. Static and seismic displacement/depth profiles were generated and analysed for the embankment as well as for the piles influenced by the embankment.

The resulting displacements highlighted that, by cutting out conservatism usually associated with LRFD design, there was no longer a need for ground improvement at the bridge abutments, which resulted in significant savings in money, construction time and material. This case study demonstrates that investment into smart design, can result in significant returns on time and money.

THERMAL METAL SPRAY STANDARDS AND NEW ZEALAND BRIDGES

Mr Willie Mandeno[1]
[1]WSP, Wellington, New Zealand

Session 6B, Brooklyn 2, July 9, 2024, 10:30 AM - 12:30 PM

The presentation reviews the development of Standards and Guides for protective coatings used by designers of steel bridges in New Zealand, with emphasis on the use of thermal metal spray (TMS) and the soon to be published Part 3 of AS/NZS 2312 'Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings'. The contents of this draft that is currently out for public comment are reviewed and new features are highlighted, together with illustrated examples of bridge structures in NZ that have been given long term protection against corrosion with thermal metal spray.

TUNNEL LINING DESIGN FOR MT MESSENGER BYPASS PROJECT

Ms Katerina Howard[1]
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Session 7B, Brooklyn 2, July 9, 2024, 1:30 PM - 3:30 PM

The Mt Messenger Bypass Project comprises a new 6 km road from Uruti to Ahititi to avoid the existing steep, narrow and winding route over Mt Messenger on SH3. The new alignment includes a 235m long tunnel.
The tunnel passes about 80 m below the existing ground level through a prominent ridgeline which leads to the local topographic high point of Mt Messenger.

The detailed design for the single-pass tunnel lining which comprises of temporary and permanent support elements is presented together with the optimised excavation sequence that was designed in response to programme challenges.

The proposed tunnel is approximately 12 m wide and 9 m high to allow passage of over-size vehicles and will be excavated using sequential excavation method through the Mount Messenger Formation rock which is generally massive to indistinctly bedded Siltstone, interbedded Siltstone/Sandstone, and Sandstone.
The detailed design is currently in the final review stage and due for construction start at the turn of July/August 2024.

USING SITE-SPECIFIC SEISMIC HAZARD ASSESSMENTS TO OPTIMIZE GROUND IMPROVEMENT

Mr Ben Mckay[1], Mr Kori Lentfer[1], Mr Harshad Phadnis[1]
[1]CMW Geosciences, Hamilton, New Zealand

Session 6A, Heaphy 2&3, July 9, 2024, 10:30 AM - 12:30 PM

As development across New Zealand continues to spread beyond existing city limits, sub-prime development locations are increasingly selected due to their vicinity to existing population centres. One of the major challenges in these locations in New Zealand is seismic risk and associated hazards like liquefaction, cyclic softening, seismic instability including flow failure and lateral spreading. Design seismic loading is routinely obtained from national standards or equivalent documents.

A Site-Specific Seismic Hazard Assessment (SSSHA) can be performed to calculate the design seismic loads at a site as a function of return periods. A SSSHA is usually performed for more critical infrastructure, rather than for residential development.

This paper presents a case study of a residential land development project in Cambridge, New Zealand, where a SSSHA was performed based on which the peak ground acceleration for the ULS loading (500 years) was reduced from 0.28g to 0.17g. The resultant modelling of the site indicated a significant reduction in calculated lateral spread and slope instability risk, which lead to substantial construction cost savings and reduced carbon emissions associated with the development. This was a critical part of the development design, which ultimately allowed the project to proceed from a feasibility study to construction.

WAIPUNA BRIDGE HALF JOINT EXPANSION JOINTS REPLACEMENT

Mr. ZHONGYI LI[1], Dr. Gang Yu[1]
[1]Auckland Transport, Auckland, New Zealand

Session 3B, Brooklyn 2, July 8, 2024, 1:30 PM - 3:30 PM

Waipuna Bridge has the highest network criticality rating. It is one of the two crossings between Auckland's Central and Eastern suburbs across the Tamaki River. It has four lanes and peak traffic volumes of 60,000 vehicles/day in each direction. It is a nine-span post-tensioned bridge constructed in 1974 and carries one of Auckland's 440kVA power supply cable sets.

The original expansion joints were not watertight and were due for replacement. The inspection revealed alkali-silica reaction (ASR) type cracking underneath the half joints and corrosion of the vertical tendon anchor plates.

The proposed expansion joints are different to the original ones. This difference lies in various factors, such as dimensions, embedment depth, reinforcement layout, concrete material for the nosing, etc. Therefore, the construction methodology had to accommodate these factors for the new expansion joints.

The key to delivery was securing the window of opportunity to carry out the main installation. To do that, the traffic management layout with the traffic impact assessment had to be agreed upon with various road controlling authorities.

The chosen traffic management layout was an alternating 24-hour bridge half-closure during the 2023 Christmas and New Year holidays. Two lanes were closed while the rest were kept live in each direction. Correspondingly, the closure's Traffic Management Impact was thoroughly assessed at both network and local road levels.

Stakeholder management was important. Multiple stakeholders were identified and consulted through the delivery phases. Auckland System Management (ASM) and ATOC contributed to the VMS messaging and phasing for various traffic scenarios to the state highway and local road users. Moreover, the AT Corridor Assess Team was reviewing traffic management plans along with ATOC. In addition, local businesses, the heavy vehicle industry, emergency services and local boards were updated.

Construction supervision was crucial. First, urgent on-site issues were resolved promptly. For example, the drilling depth could be controlled without damaging the post-tension tendons. The rubber seal installation was resolved on site as it was ambiguous from the plans. The method of alleviating the hogging of the installed expansion joint was discussed and confirmed. In addition, any acceleration opportunities could be pursued. For instance, the construction programme was halved by shifting the closure phasing within the approved TMP clauses.

In conclusion, the expansion installation was successfully completed during the 2023 Christmas and New Year holidays, halving its original construction programme. There were no construction site-related complaints.

WAIROA RIVER BRIDGE: NU ADVANCES IN SUPERSTRUCTURE DESIGN EFFICIENCY

Mr Dan Ashby[1]
[1]Holmes NZ, Wellington, New Zealand

Session 7B, Brooklyn 2, July 9, 2024, 1:30 PM - 3:30 PM

This presentation provides an overview of the design of the new 10-span 350m long Wairoa River Bridge which will carry the Takitimu North Link Expressway across the Wairoa River and adjacent flood plain. Spanning soft liquefiable flood plain deposits, with the founding strata being at depths in excess of 30m, the site seismicity and soil conditions presented considerable design challenges.

This structure makes use of a new precast girder I-section, which was developed in collaboration with the contractor and precaster. The new section shape is based on the Nebraska University (NU) Girder used in North America, making efficient use of modern high-strength concrete materials, and allowing for post tensioning through the girder webs, with modification to provide concrete covers suitable to the New Zealand environment, reduce form fabrication costs, and accommodate the constraints of existing precast casting bed geometries. A modular precast form allows a variety of section depths to be utilized, paving the way for the more widespread use of a highly efficient girder system capable of reaching significantly greater spans than can be achieved with existing precast girders currently used in the NZ market.

Also contributing significantly to the material savings was the innovative use of extruded polystyrene strips to seat precast deck panels, allowing for variation in girder hog to be accommodated while maintaining a constant-thickness structural deck thickness. The resulting deck weight reduction is amplified by proportional savings in both the supporting girders, piers, and foundations, and in turn reduced seismic inertial actions. Reduced foundation demands allowed for a large-column on small-pile configuration, providing strength and stiffness where needed, eliminating the need for pile caps, and with the reduced pile diameters giving a significant savings given the number and founding depths of the piles.

This highly efficient design was estimated to use less than 65% of the materials that may be seen in a contemporary Super T bridge superstructure at the same site, with proportionate construction cost savings and reduced carbon footprint.