FROM DISUSED OFFRAMP TO NEW URBAN SPACE

Practice Paper

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ABSTRACT

The Nelson Street Offramp had stood unused for 10 years when NZ Transport Agency (NZTA) decided to utilise it as part of Auckland's growing cycling network. This follows a trend of turning redundant transport infrastructure into great urban and active transport spaces, seen also in The Highline in New York and 606 in Chicago amongst others.

Unlike these projects however, this project is outstanding in how quickly it has been designed and delivered in Auckland. In October 2014 GHD was contracted to undertake design and construction of the project, with partners Novare Design and architects Monk Mckenzie completing the Canada Street Bridge design. What would have usually taken at least 2 years to design and retrofit/build was condensed into almost half that time, prompting Cycle Action Auckland to say the follow about the project:

> *"From conception to delivery in barely a year?! Unheard of! Success has many fathers, and necessity is the mother of you-know-what, and after a close-up view of what's happening, I reckon we will all be delighted to lay claim to this baby."*

The fast delivery of the project involved high levels of collaboration and design expertise between all project partners to deliver an active transport link for the people of Auckland. This paper will discuss how this redundant offramp was rapidly transformed into a colourful and beautiful new urban space, which will add a whole new character to the Central Motorway Junction.

INTRODUCTION

> *"From conception to delivery in barely a year?! Unheard of! Success has many fathers, and necessity is the mother of you-know-what, and after a close-up view of what's happening, I reckon we will all be delighted to lay claim to this baby."*
> (Cycle Action Auckland, 2015)

This quote from Cycle Action Auckland refers to the achievement of delivering this striking and colourful project from scheme assessment to cycleway opening within just 14 months. How was this achieved, and what engineering skills and knowhow guided its delivery?

To critique this subject, this paper will guide you through some of the key challenges faced by GHD's design and construction supervision team. It will highlight how these challenges were addressed, how the project evolved as a result of these challenges, and how the project maintained delivery under an accelerated timeframe. The accelerated nature and project timeline will form the thematic structure of the paper.

Following this structure, the paper will highlight some of the key skills and competences required to deliver the project successfully. This will be achieved by illustrating the various theories and principles applied to problem solving along the way to achieve a successful outcome. Finally, the the discourse will be consolidated to pose a response to the question: how was this unique project delivered within just 14 months?

PROJECT LOCATION AND DESCRIPTION

The project consists of a new cycleway between Upper Queen Street and Nelson Street via the disused Old Nelson Street Offramp, within Auckland's Central Motorway Junction. The cycleway provides greater connectivity to Auckland's cycle network by linking Grafton Gulley Cycleway, at Upper Queen Street, to the wider central city cycleway network, at Nelson Street. The Central Motorway Junction Walking and Cycling Masterplan (2012) identified that the Old Nelson Street Offramp could provide good walking and cycling connections and enhance the area through the Central Motorway Junction.

The disused Old Nelson Street Offramp begins south of Karangahape Road diverging from the right-hand side of SH1, northbound, and ends at the intersection of Nelson Street, Union Street and Pitt Street (Figure 1). It has been redundant as part of the Central Motorway Junction upgrade and is currently unused. The offramp is approximately 7m wide and 670m long and is assessed to be in good structurally condition.

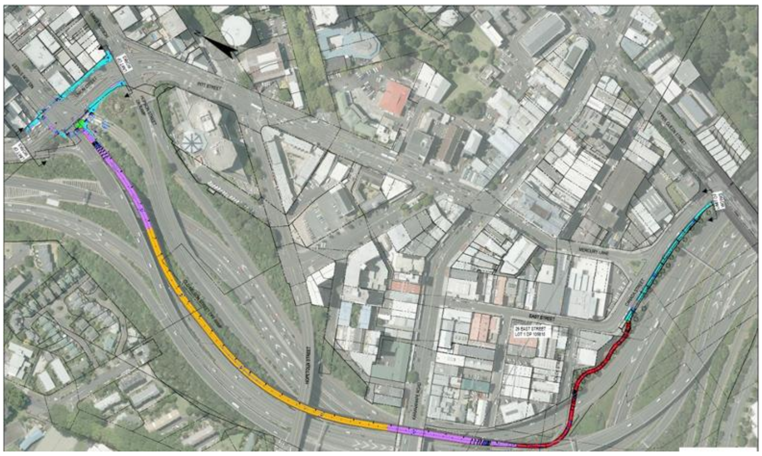

Figure 1 – Old Nelson St Offramp with Auckland's Central Motorway Junction

SCHEME ASSESSMENT AND BACKGROUND

GHD was awarded the professional service commission to deliver the project in October 2014. Their role was defined as lead consultant responsible for the design management of the overall project, including construction supervision responsibilities (Engineer to Contract and Engineers Representative) under NZS3910:2013. Novare Design was responsible for delivering the structural design of Canada Street Bridge, with Monk Mackenzie providing Architectural direction for the entire project. Together the core team of GHD, Novare and Monk Mackenzie were faced with the following design challenges from the outset:

- Deliver a cycleway by Summer 2015, including bridging SH1 to provide a new connection.
- Scheme assessment and design of a new 1km cycleway requiring major infrastructure design.
- Utilizing a disused existing offramp to fit new infrastructure.
- Obtain building and resource consents required within this accelerated timeframe.
- Keep the offramp available for use as an emergency detour for cars and light vehicles.
- Geometric challenges – design for cars versus cyclists and pedestrians.

The initial challenge faced by the team was to update the scheme assessment report and select the optimum route which best met geometric challenges, safety concerns, structural viability, CPTED (Crime Prevention Through Environmental Design) recommendations, consentability and security concerns.

The Auckland Motorway Authority (AMA) had completed an options report (2014) identifying a bridge connection to South Street as the preferred option (figure 2). Going back to first principles, GHD provided 6 more options, 4 of which were a variation of AMAs preferred option. However, it immediately became apparent that the South Street options had key safety and geometry issues, which did not make them viable options.

The remaining options, both new options generated by GHD scheme assessment, were as follows:

- Option 5 - Shared path on one section of Canada Street leading to an off road cycleway on NZTA designated land
- Option 6 - Fully off road cycleway on NZTA designated land

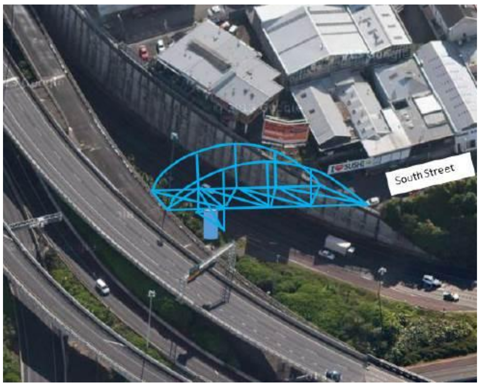

Figure 2 – South St Connection (original option)

Analyses of these options against the subject matter; delivered within just 14 months, demonstrates some of the holistic reasoning (constraints and opportunities) that guided the team's decision making. By choosing routes on an existing NZTA designation significantly reduced consenting and consultation programme risk, but increased the engineering complexity. This 'blue skies' thinking challenged the norm of the previous scheme assessment (AMA, 2014) and considered ways to repurpose otherwise redundant NZTA land, whilst also successfully addressing the critical criteria. It identified risks out of the team's control, such as consenting, and exchanged these for engineering complexity risks, that could be managed by the team.

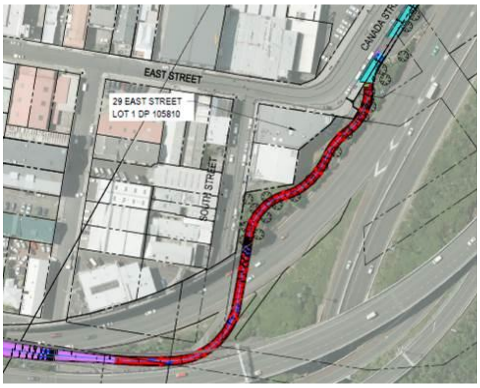

Figure 3 – Canada St Connection (preferred option/ final route)

Weighing up all the factors, Option 5 was chosen; in particular this option had reduced cost, liaison and consultation requirements with stakeholders, construction complexity and fundamentally reduced programme duration and risk.

EARLY DESIGN AND PLANNING CHALLENGES

Option 5 (herein the preferred option) brought with it many engineering challenges, in particular the steep topography of the land, pressed between a business property and State Highway 1. Analysing these constraints and completing a balanced scheme assessment required sound engineering judgement of design and construction capabilities.

However, upon undertaking the detailed design an emerging issue became apparent: the embankment was a designated 100 year overland flowpath. This posed a significant threat, reintroducing consenting programme risk and adding another level of engineering complexity. The scheme assessment design was for a bridge across the motorway, with a retaining structure carrying the cycleway along the embankment.

Once again, the team took a first principles approach and viewed the situation as both a constraint and opportunity. The existing retaining structure came with its own difficulties: how to incorporate the overland flow path, and how to negotiate around the existing services within the embankment. All of this could be engineered, but at a higher cost than a standard retaining structure, which opened the review to investigate more creative solutions; not forgetting the overriding programme implication of consenting.

Following a risk and opportunity review (including feasibility), extending the bridge (doubling its length) to traverse over the overland flowpath, avoid services and remove consenting programme risk was identified as a manageable and workable solution. However, this change came within weeks of the tender launch and updates needed to be managed in a staged approach during the tender process, with every effort made not to delay the Summer 2015 opening date.

Figure 4 – Bridge Panorama showing bridge continue along embankment (view from SH1 median)

Canada Street Bridge

The Canada St Bridge was designed by Novare Design consultancy and spans one of the busiest sections of the NZ road network, connecting Canada Street to the old offramp. The bridge was shortlisted for the Infrastructure Future Project Award at the 2015 World Architectural Awards in Singapore.

However, the bridge's form was actually guided by its transportation function, to span a maximum distance of 54m over State Highway 1, whilst minimising traffic disruption. The engineering solution was to design a steel structure, whose components could be prefabricated offsite and then safely lifted (hence steel design) into place in overnight road closures, minimising disturbance to road users whilst spanning the required distances. In total, the bridge is made of 7 spans and is 160m long.

The bridge design followed AUSTROADS Cycleway Guidelines as adopted on Grafton Gully Cycleway. The specifics of the bridge include:

- Width 3.5m.
- Camber 2%.
- Minimum Radius 24m.
- Maximum Gradient 4.4%.
- Barrier 1.4m high.
- Bridge landing onto an offramp which is in a 10% camber.

Due to the complex geometrical requirements of the space available, the bridge has five horizontal curves, with two different radii.

Figure 5 – Beam 2 lift (52m and 95tons)

TRANSFORMATION OF A DISUSED OFFRAMP TO NEW URBAN SPACE

From scheme assessment, through detailed design, to tender launch within 2 ½ months: this required clear direction and an ability to follow established codes, standards and practices. However, their were also non-standard transportation components, such as the offramp screens, which lacked a rigid standard approach. This required close liaison with the asset owner, represented by the AMA, to draft up firmer design parameters. These parameters were primarily based on maintenance considerations as well as end user experience (cyclist and pedestrians). However, given the rapid timeframe to tender launch (then tender design freeze) and with more time to deliberate during the tender period, these parameters were re-evaluated and adjusted.

This adjustment would result in both an improvement for the maintaining authority and end user, but it was not a necessary modification, rather an opportunity for improvement. The fundamental change meant the screens could be placed in front of the existing guardrail (figure 6), as opposed to placing the guardrail in front (figure 7). The advantages to this new design philosophy included:

- Greater access for maintenance - Plexiglas and perforated screen ratio no longer governed by the barrier height meaning the ratio could be developed to improve access behind the screen (larger perforated panel).
- Standardisation – posts and connections could be standardise for maintenance.
- Safety – with the screens now placed in front of the guardrail, this removed any protruding objects (such as guardrail) which could impede cyclists
- Aesthetics – Screen façade now independent of the guardrail.
- Reduced costs – standard sizes and connection detail reduced construction and whole-of-life costs.

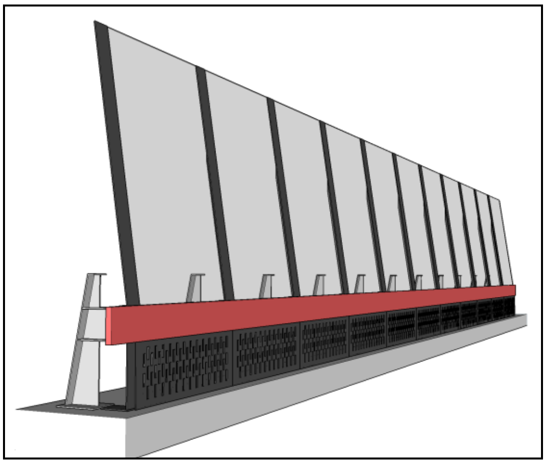

Figure 6 – Original design with guardrail (shown in red) attached to the front

Figure 7 – New design with guardrail to rear (perforated panels installed on left)

However, this redesign would have to be managed during construction as part of a value engineering exercise with Hawkins (main contractor). Given the already restricted timeframe, change management would need to be carefully monitored so as not to impact on the programme. The project team (including Hawkins) would also need to quickly establish a cohesive collaborative working relationship. Some of the key design challenges to retrofitting new screens (and other infrastructure) to the old offramp included:

- Avoid existing reinforcement in the bridge deck.
- The volume of post on the offramp were in excess of 600.
- The gradient of the existing offramp reach a camber of 10%.
- The guardrail upright were unevenly spaced and varied in distance from 1.1 to 2.2m apart (green arrow, shown on figure 8).

- The guardrail was not uniform, which affected the connection tolerances, as shown follow:
  Eastern side
  - Height of barrier (red) centre point varies from 520mm to 575mm
  - Bolt spacing (orange) varies from 100-120mm centres
  - Barrier width either 230mm or 245mm (2 types)

  Western side
  - Height of barrier (red) centre point varies from 490 mm to 550 mm
  - Bolt spacing (orange) varies from 100-120 mm and 210-230 mm centres (2 types)
  - Barrier width either 230mm or 245mm (2 types)

Figure 8 – Existing Barrier Dimension

Working from first principles to try develop a best for project solution, the team set their brief to: developing a standardised post/connections detail that could arrive on site prefabricated (including painted) and then bolted into place, with no welding or corrosion protection required. To achieve this goal required a number of challenging and collaborative innovation sessions. Some of the novel design solutions created to address these constraints were (see figure 9):

- Reinforcement: to avoid reinforcement, each base plate had 3 options in each corner to make 1 bolted connection.
- Maintenance: the perforated panel increased to 1.2m high (from 300mm) to provide greater access for maintenance.
- Accessibility: the Plexiglas and perforated panel were design to be opened independent and safely of each other. This meant that the perforated panel could be removed for the majority of maintenance activities, keeping the Plexiglas in place and providing a safer worksite.
- Uneven spacing: a slotted shelf detail was designed to accommodate the varying distance between guardrail uprights (structurally column needed to tie-in at guardrail upright).
- Uneven panel widths: the uneven spacing of column uprights meant that each perforated panel and Plexiglas panel would have to be cut to a unique width. However, the design of a 200mm clamping plate system, placed in front of the column, provided sufficient tolerance behind the plate to significantly reduce the number of width variance; with 14 standard panel widths, from over 600 unevenly spaced posts.

Figure 9 - Barrier Connection

- Standardise connection detail: this resulted in 18 post variations capable of covering all guardrail connection variances on the offramp.
- Standardise product: posts could be prefabrication and corrosion protected off-site, meaning no welding or corrosion protection on site, enabling better quality control.
- Aesthetics and safety: the screen overlaps, shelf, Plexiglas, Plexiglas gusset and perforated panel, were carefully design to provide a uniform even facade, which required staggered coupling nuts and spacer detail to the millimetre accuracy.

Undeterred by time constraints, the project team value engineered a new solution from first principles during construction, with no impact to the programme and achieving both construction and whole-of-life cost savings.

Emergency Access

Another transportation design consideration was to maintain emergency access from SH1 for cars and light vehicles. This was to facilitate the use of the existing removable barrier along SH1 in emergency situations only. To accommodate this, a sliding gate was designed within the 3m screen capable of providing vehicle access to the offramp behind the existing emergency barriers. Egress (and access) points at Union Street were also designed, in addition to an access point specifically for larger vehicles required for maintenance. This was accommodated by designing a removable fence at SH1 offramp's intersection with Union Street. All access and egress points were designed to be safely and manually operated by the AMA and designed in discussion with AMA using vehicle tracking paths.

Visual and Social Enhancements

Following the screen redesign and towards the mid-point of construction, further enhancements were proposed which were outside the scope of the original works. Inspired by the unique location and the emerging Canada Street Bridge, NZTA together with Auckland Council set about investigating potential enhancements to the offramp.

At this point, Monk Mackenzie (project architects) was re-tasked with developing concepts for offramp enhancements. What followed was a series of concept workshops where the project team, in particular GHD and Hawkins, reviewed the constructability and programme implications of the options and advised on what could be achievable given the stage of construction. Following this initial phase of iterative workshops, it was decided to take the following concepts to detailed design and construction:

- Maori Artwork: In the form of 15 etched steel carvings of humanistic figures along the cycleway, in addition to a 6m high carved steel post marking the entrance to the offramp (Pou). These etchings/carvings were designed by a local Maori artist taking the history of the land and the people into consideration.
- Magenta surfacing on the offramp (including a Koru design): Engaging a local Maori artist again, the magenta surface was chosen due to its reference to the heartwood of the totara tree, a colour that comes from the land. This feature is not only distinctly New Zealand, but also reflects the ‘modern’ public consultation directive.
- Interactive Lighting Design: 290 LED columns, each 3m high with motion sensor light automotive design. Lighting capable of mimicking either pedestrians or cyclists movements enhancing their experience.

This was a substantial design change mid-construction and required complete collaboration from the project team, in particular between the designers and contractor. Some examples of the level of complexity were as follows:

- Specialist materials needed to be ordered from Israel, USA, France and UK almost immediately, before designs were finalised.
- The 290 LED columns are completely unique design, bespoke to this project.

- How to incorporate the sensor design for these new LEDs into the existing infrastructure.
- Necessity to redesign all the street lighting and CCTV on the offramp. The existing design had lighting and CCTV balanced on both sides of the offramp, with the new design moving all components to the eastern side.
- Trailing and sourcing suppliers for feature products such as the magenta surfacing or unique products such as outdoor UV protected data and power parallel trunking (data needed protection from power interference)
- The addition of 17 new columns which were in advance of the offramp (no guardrail), requiring new footing, ducting and post designs.

Overall an entire new construction drawing series for these components was produced by GHD and Monk Mackenzie within 3 weeks for immediate construction (or steel prefabrication). This was another occasion where ingenuity and designing from first principles was necessary, guided by engineering judgement, with change controlled applied using project management principles.

These changes, outside the scope of the original works, resulted in an approximate 4 week extension of time, which brought the works up to the end of spring 2015 (30 November). This was no coincidence, as part of the original workshopping process; the team was tasked with judging enhancement on their ability to be designed and delivered no later than the end of spring 2015, maintaining a summer 2015 opening.

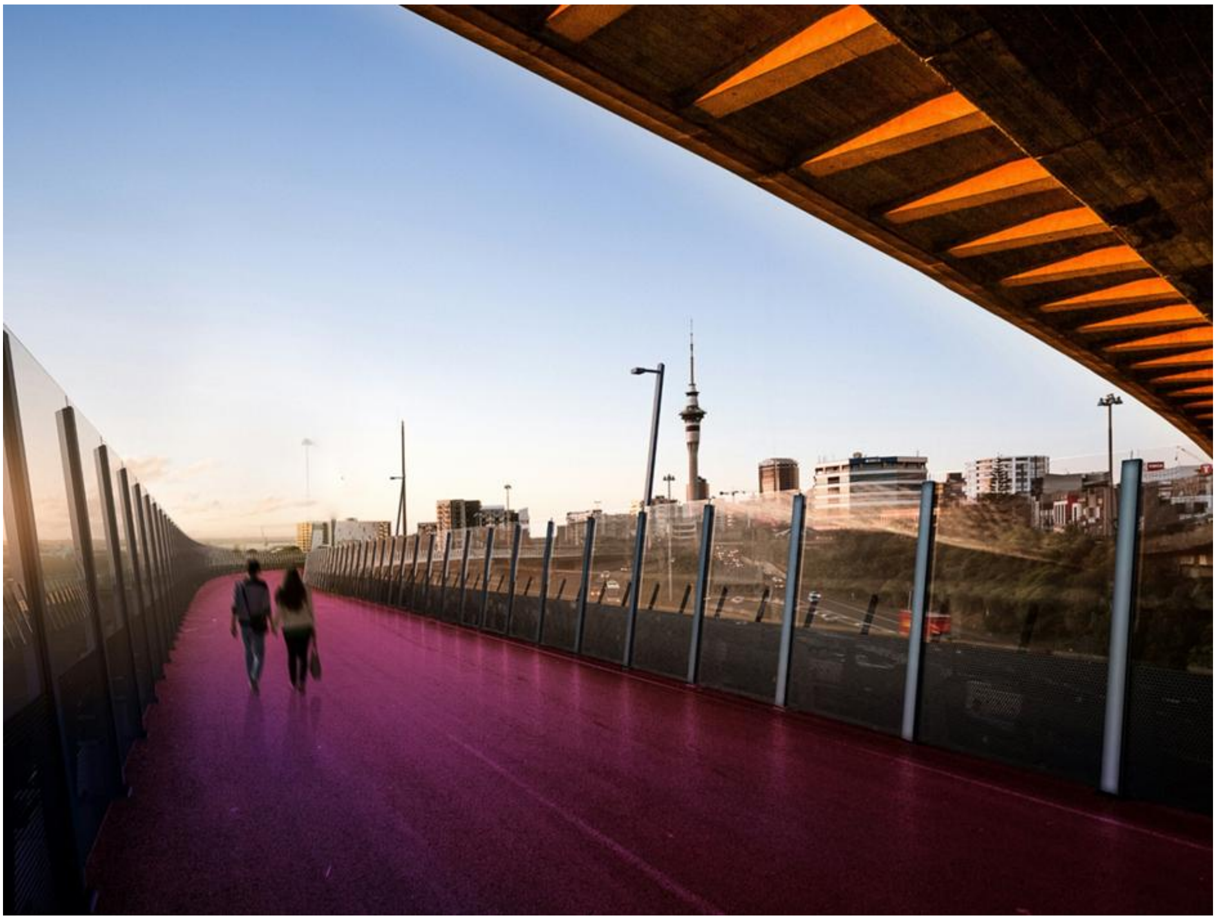

Figure 10 – Design rendering of enhancement

DISCUSSION

> *"Deal with complex engineering problems and activities requiring the application of specialist engineering knowledge and work from first principles"* capabilities of a Chartered Engineer (IPENZ, 2015)

A significant qualification within this quote is to 'work from first principles'. The importance of working from 'first principles' has been shown to be particular prevalent on this project. From the decisions to re-evaluate the scheme assessment report, extend Canada Street Bridge, value engineer the screens, to designing bespoke interactive LED columns and emergency access gates. The first step for the team was not to accept the norm, but to apply critical reasoning to the specific problem and also view the problem in its wider context, for example extending the bridge due to the overland flowpath.

This project was a mixture of both standard and non-standard infrastructure, to be constructed under an ambitious timeframe; yet the design team (notably led by chartered engineers) addressed each problem as a unique circumstance and designed each in turn for a specific purpose. Standard practices are common place in engineering but can sometimes be used as a shortcut to a solution, which may not be the optimum one. This project was shaped by challenging the norms to deliver the highly acclaimed Canada Street Bridge (Bridge Design and Engineering, 2015) and highly publicised Nelson St Offramp. As highlighted by IPENZ (2015), working from first principles is a competence expected of all chartered professional engineers.

Returning to the original questions posed by this paper: how was this project delivered within the ambitious timeframe, and what engineering skills and knowhow guided its delivery? In broad terms, one of the key success factors was the critical reasoning (working for first principles) applied by the project team to solve each problem along the way. This guided both the final shape of the project, together with its successful delivery on time. To try structure this approach, could be presented as follows:

- Take a Holistic View: starting from 'first principles', analyse each problem or design as a unique situation, take both a micro and macro view of the situation. Critically evaluate the standard practice (or network precedents) for their application to the specific challenge presented.
- Apply Engineering Judgement: use engineering judgement and reasoning, together with standard practices to guide your evaluation of solutions or new concepts.
- Maintain Control: its important to maintain clarity and control during change management and not get stifled by the risk change presents. Instead use the project management tools and systems at your disposal to manage these risks.

CONCLUSION

This paper set out to critique how this project was delivered within the ambitious timeframe, and what engineering skills and knowhow guided its delivery. This critic was derived through analyses of observed practices of GHD's design and construction team, throughout the many project challenges they faced. The theories summarised from this paper point to the importance of viewing each project (and problem) as a unique situation. To always strive for 'best for project', which sometime means a departure from establish practices, and to practice challenging problems from first principles using ingenuity and engineering judgement.

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