SMEC
Member of the Surbana Jurong Group

Bridge Design Case Studies with MIDAS

Kenny Luu – Manager, Structures ANZ
MIDAS Square - 14 November 2023, Seoul, Korea

Agenda

1. Introduction to SMEC
2. Bridge Design Case Studies with Midas
   - Commonwealth Avenue Bridge Renewal
   - Bridge widenings- An Australian example
   - Castlereagh Road Rail Bridge Replacement
   - Palasbari Bridge, India
3. Concluding Remarks

About SMEC

Our Origins

SMEC is proud of our origins on the iconic Snowy Mountains Hydroelectric Scheme which was undertaken between **1949 and 1974** bringing together over **100,000 workers** from **30 countries.**

7
power stations

16
major dams

80km
aqueducts

145km
pumping station tunnels

2000km
roads

Our Story

1949 - 1974

Snowy Mountains Hydroelectric Scheme

1967

Snowy Hydro named a wonder of the modern world

1970

Snowy Mountains Engineering Company (SMEC) was established

1980 - 1995

Continued global expansion

2000 - 2012

The new millenium

2016

SMEC joins Surbana Jurong

A global family of specialists

Australia, New Zealand & Pacific Islands
Australia
New Zealand
Fiji
Papua New Guinea
Solomon Islands

Africa
Ethiopia
Kenya
Tanzania
South Africa
Namibia

North America
Canada
US (Seattle)

North Asia
China

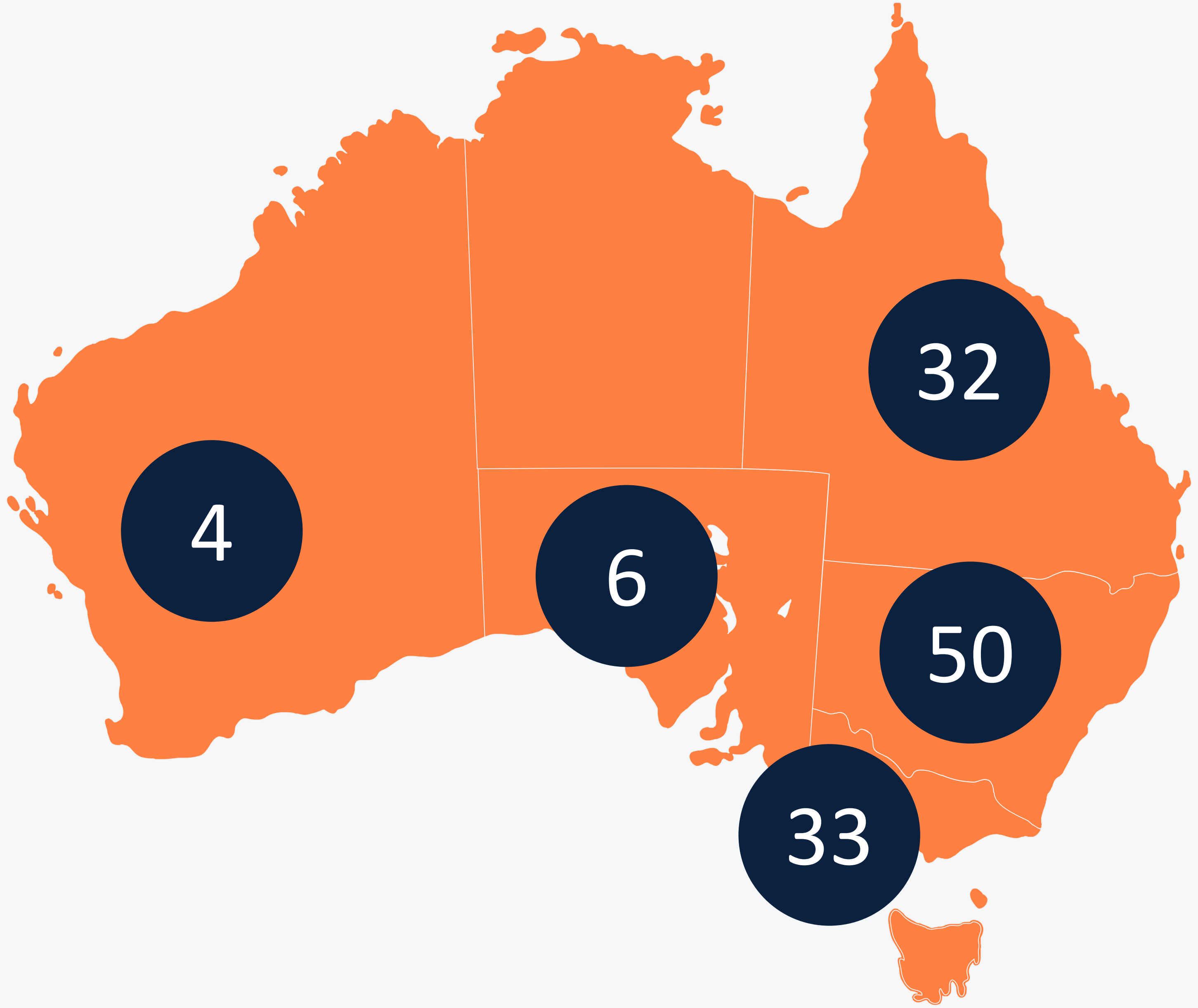
South America
Chile

South & Central Asia
Afghanistan
Bangladesh
Georgia
India
Kazakhstan
Nepal
Pakistan
Sri Lanka
Tajikistan
UAE

Southeast Asia
Singapore
Brunei
Indonesia
Malaysia
Philippines
Myanmar
Vietnam

UK
London

Our Bridges Team



Our ANZ team comprises 125 bridges and structures engineers and material specialists.

Our capability is further enhanced by the bridge teams across the SMEC International Business, including in our Global Design Centre in Bangalore and in South Africa.

Our Capabilities

HIGHWAY BRIDGES

STEEL COMPOSITE BRIDGES

LAUNCHED BRIDGES

EXTRADOSED BRIDGES

BRIDGE WIDENINGS

SEGMENTAL PRECAST BOXED GIRDERS

SEGMENTAL PRECAST - BALANCED CANTILEVER

NETWORK ARCHES – PEDESTRIAN BRIDGES

MIDAS Case Studies

Commonwealth Avenue Bridge Renewal, Australia

Castlereagh Road Rail Bridge Replacement, Australia

Bridge Widening – An example, Australia

Palasbari Bridge, India

Commonwealth Avenue Bridge Renewal

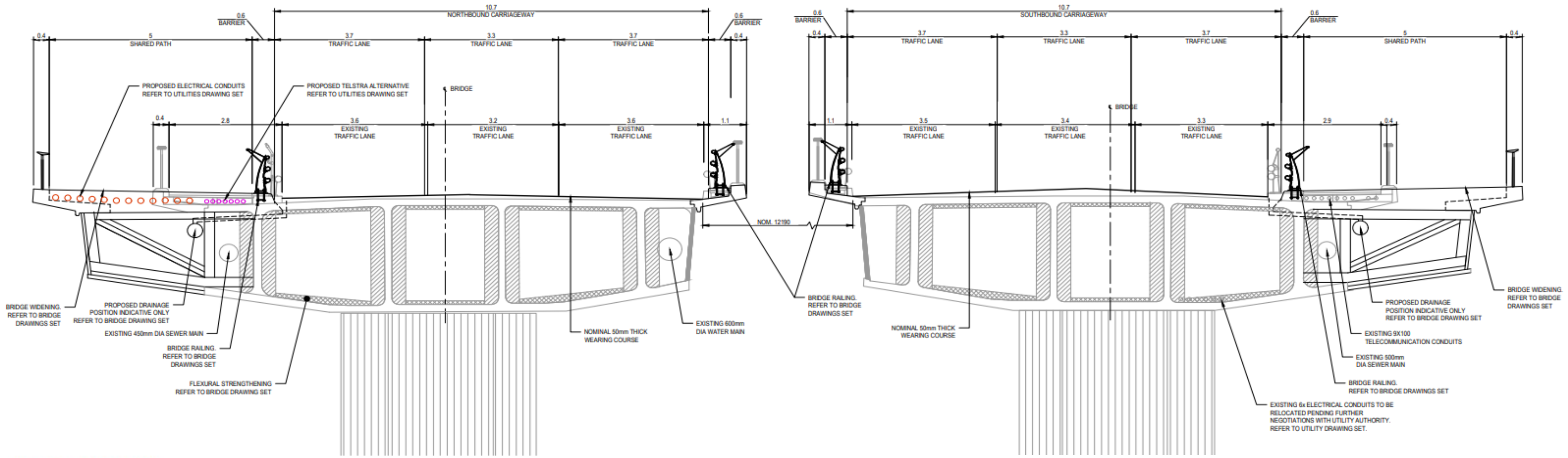
Project Overview

Image credit: NAA A1200, L7654 and NAA A1200, L7658

The Existing Bridge

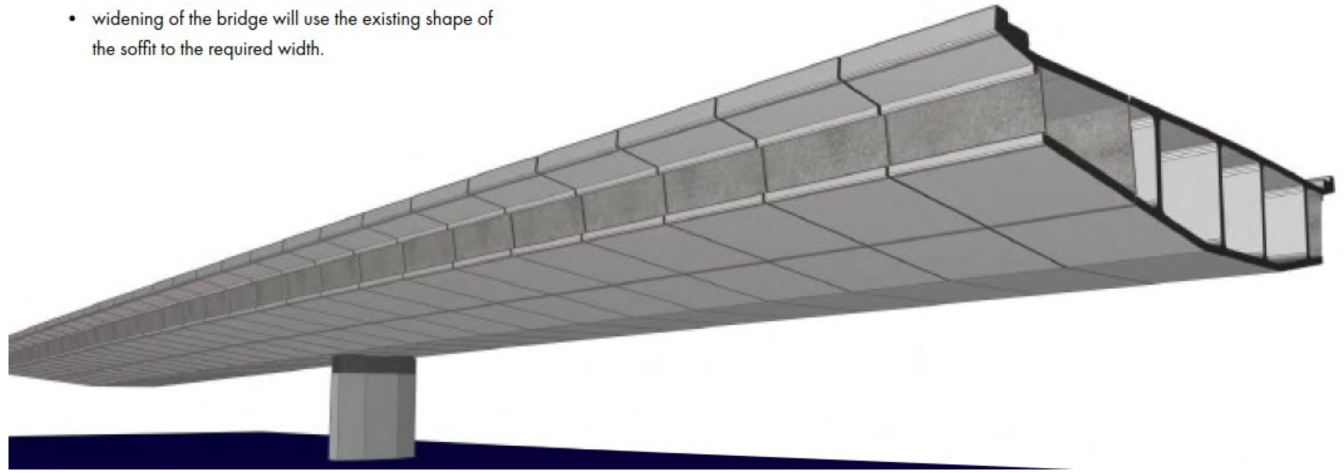
Image credit: NAA A1200, L7654 and NAA A1200, L7658

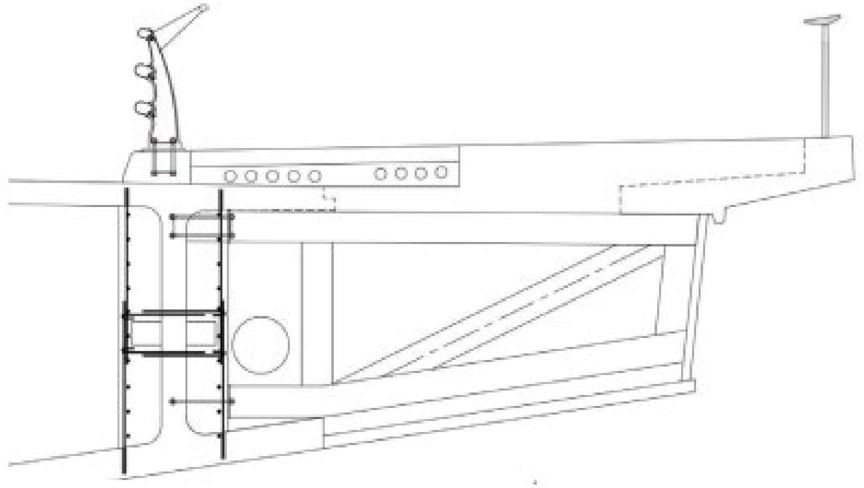
Bridge Upgrade Works



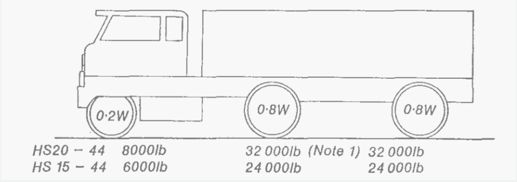
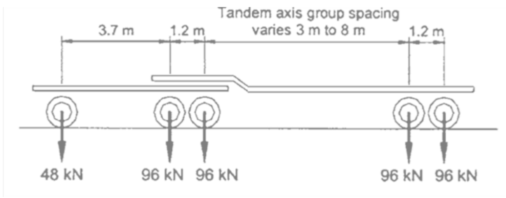
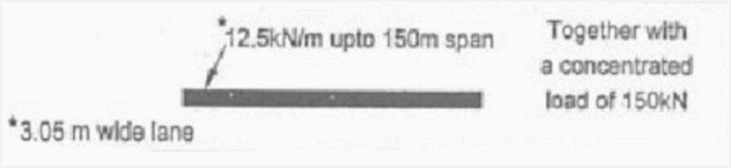
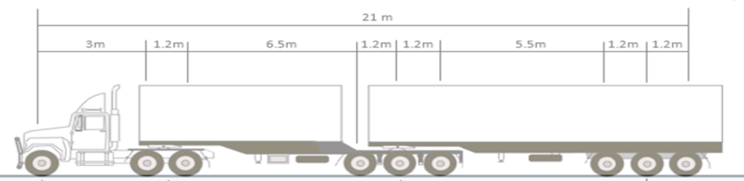
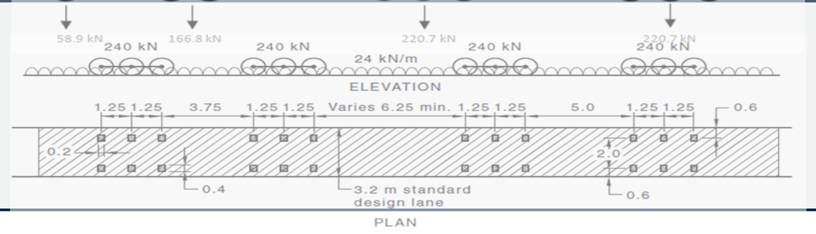
DESIGN ELEMENTS

- widening of the bridge will use the existing shape of the soffit to the required width.

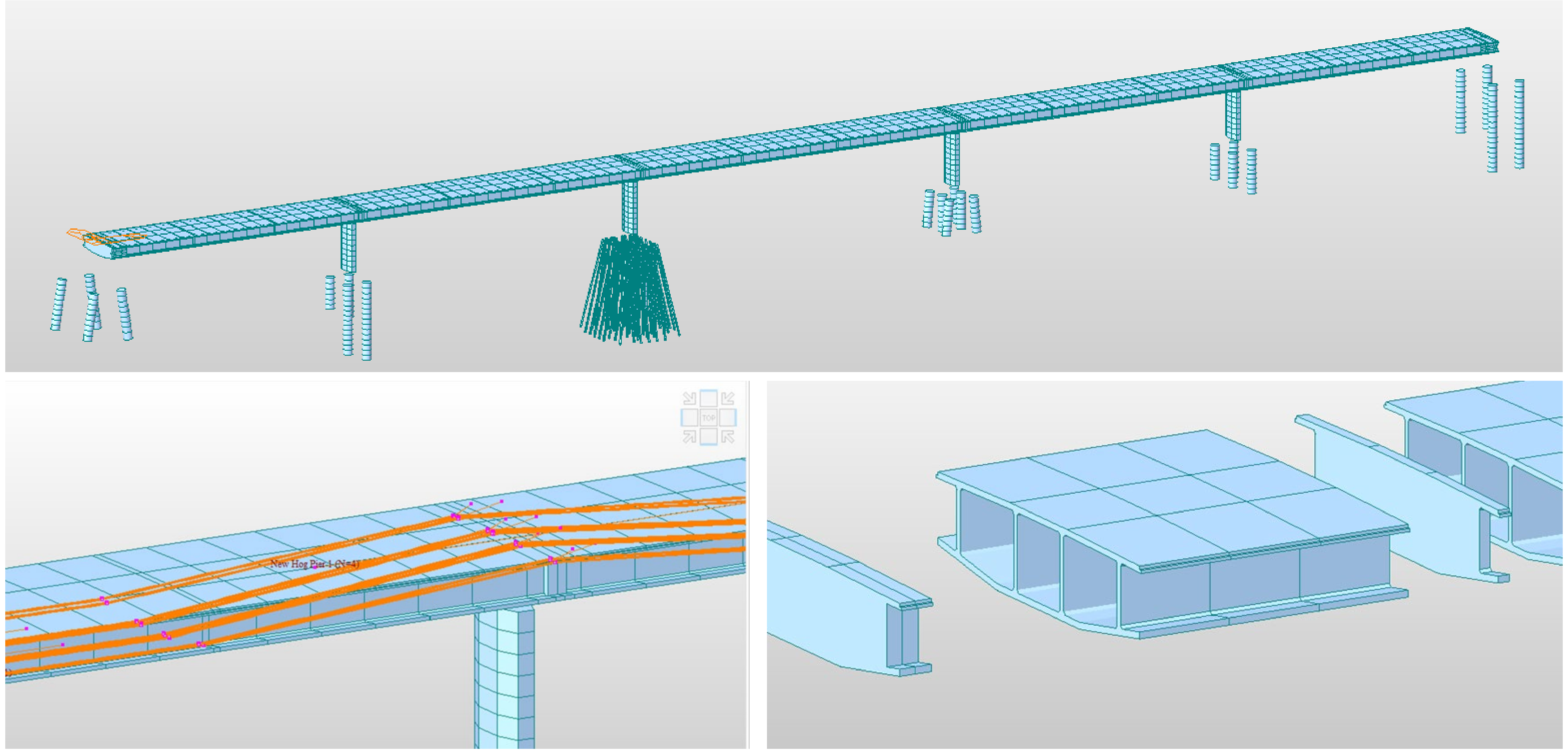




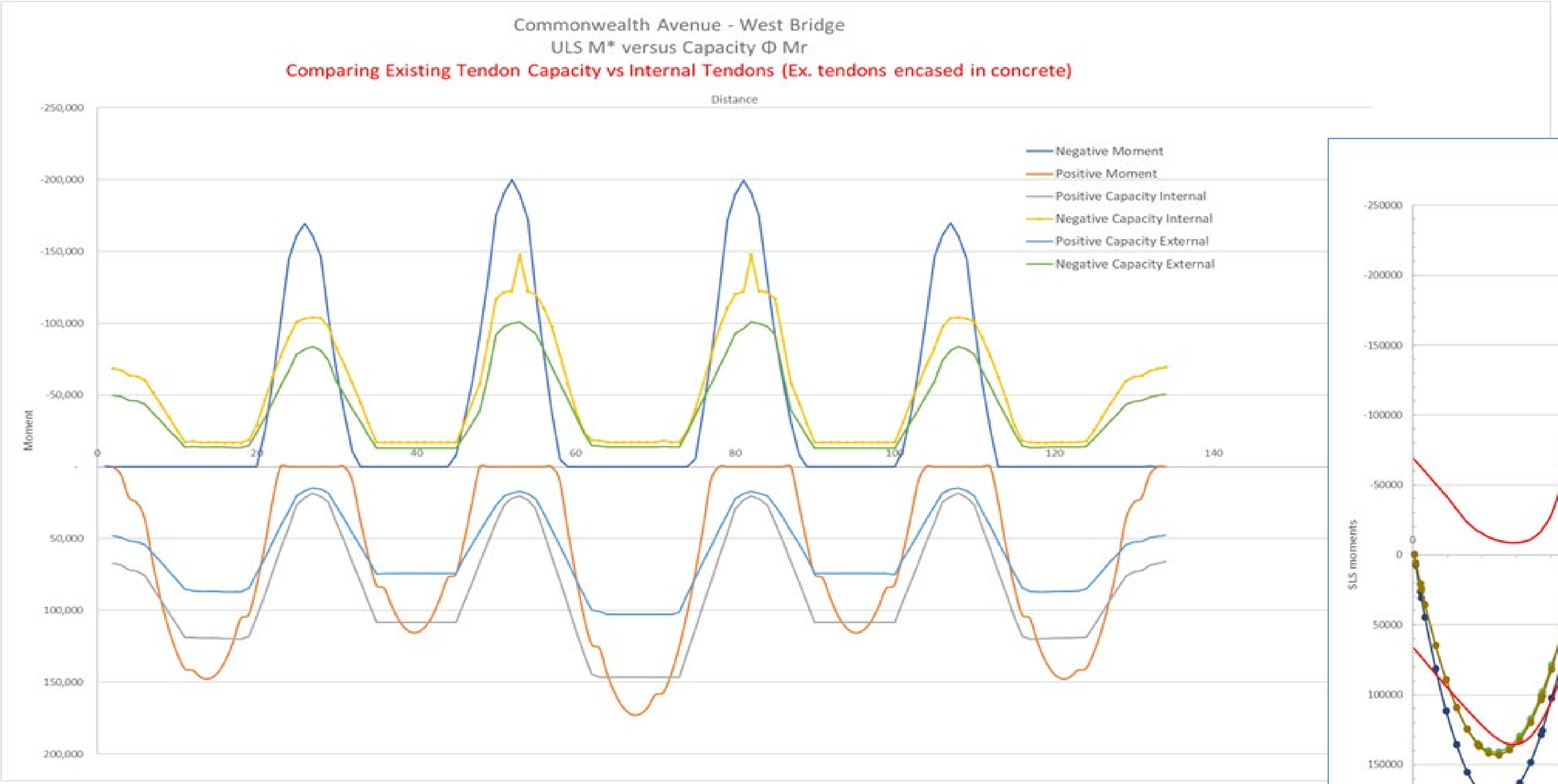
Bridge Upgrade Works – Live loading

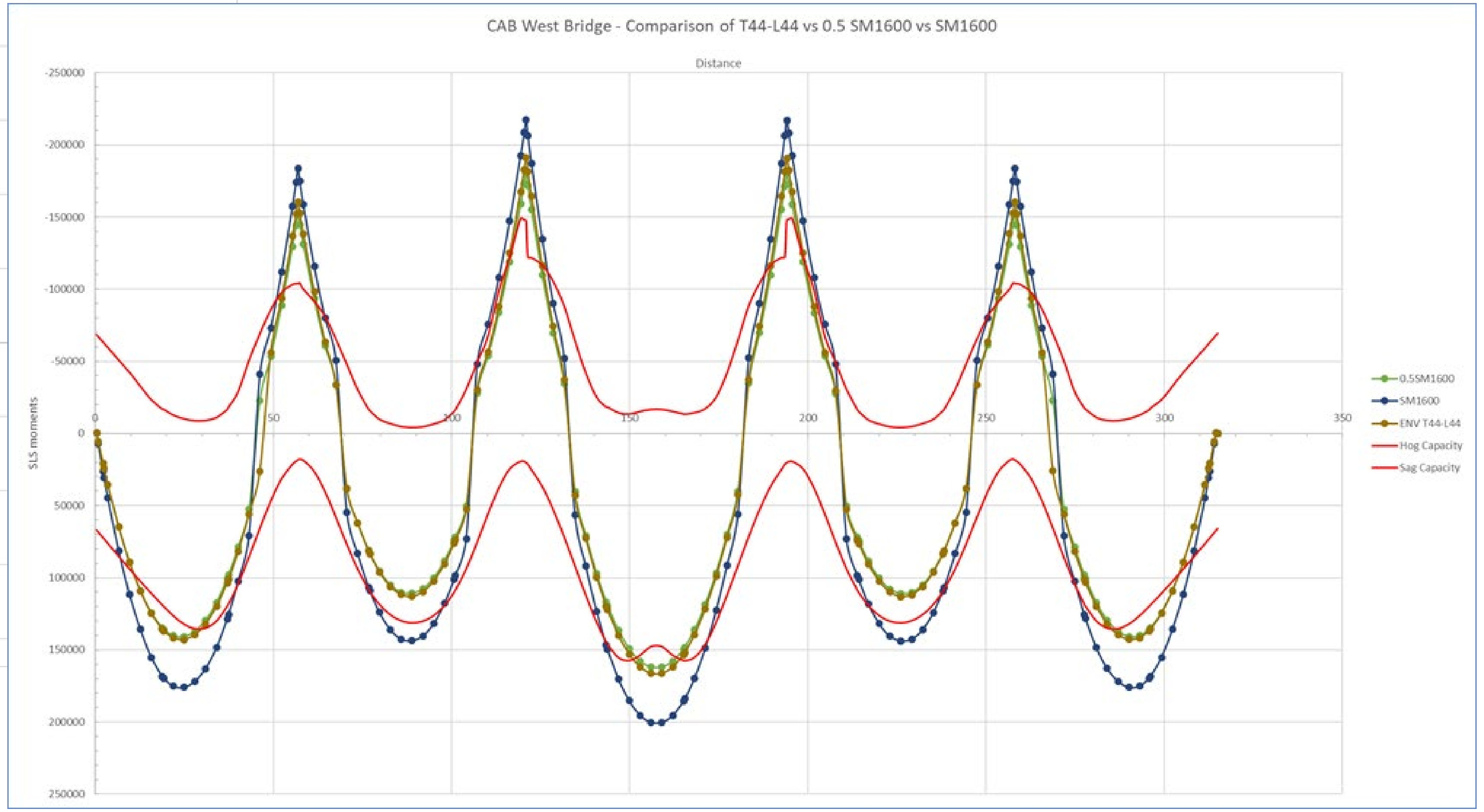
Vehicle Type	Design Loading	Remarks
HS20-44		30 T Truck, Original Design, Highway Bridge Specification 1958
T44		44T Truck, NAASRA 1972, AustRoads Bridge Design Code 1992
L44		44T Patch Load, NAASRA 1972, AustRoads Bridge Design Code 1992
BD-68		68T Higher Mass Limit Vehicle
M1600		160 T Truck, AS5100-2017

Bridge Upgrade Works – MIDAS Model

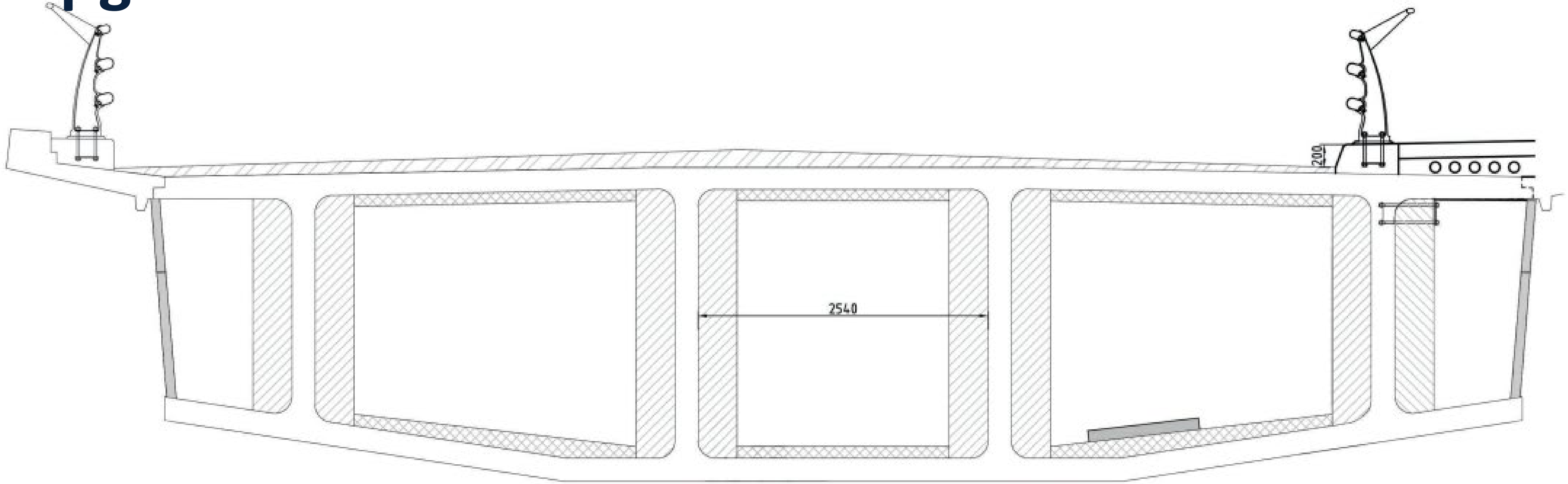


Bridge Upgrade Works – Assessment Outcomes

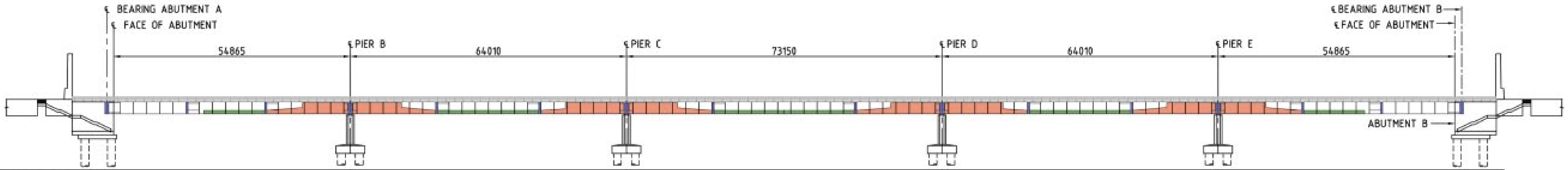




Bridge Upgrade Works – Assessment Outcomes



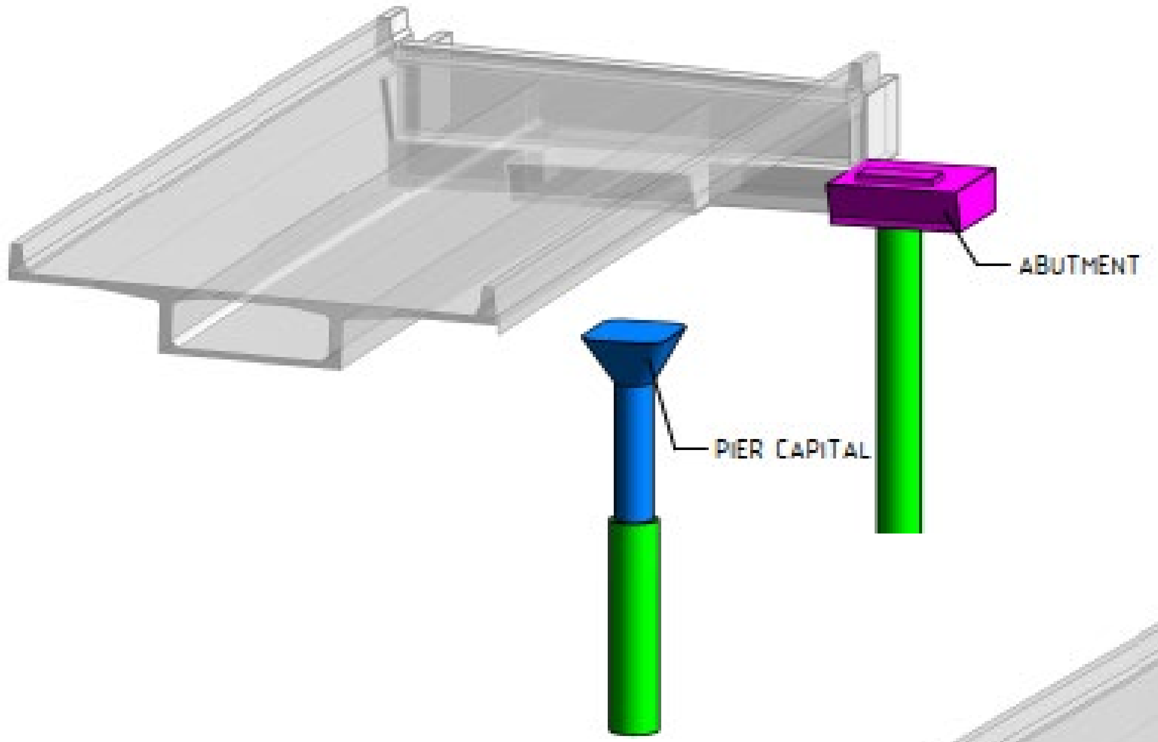
PROPOSED STRENGTHENING WORKS CROSS SECTION - SOUTH BOUND

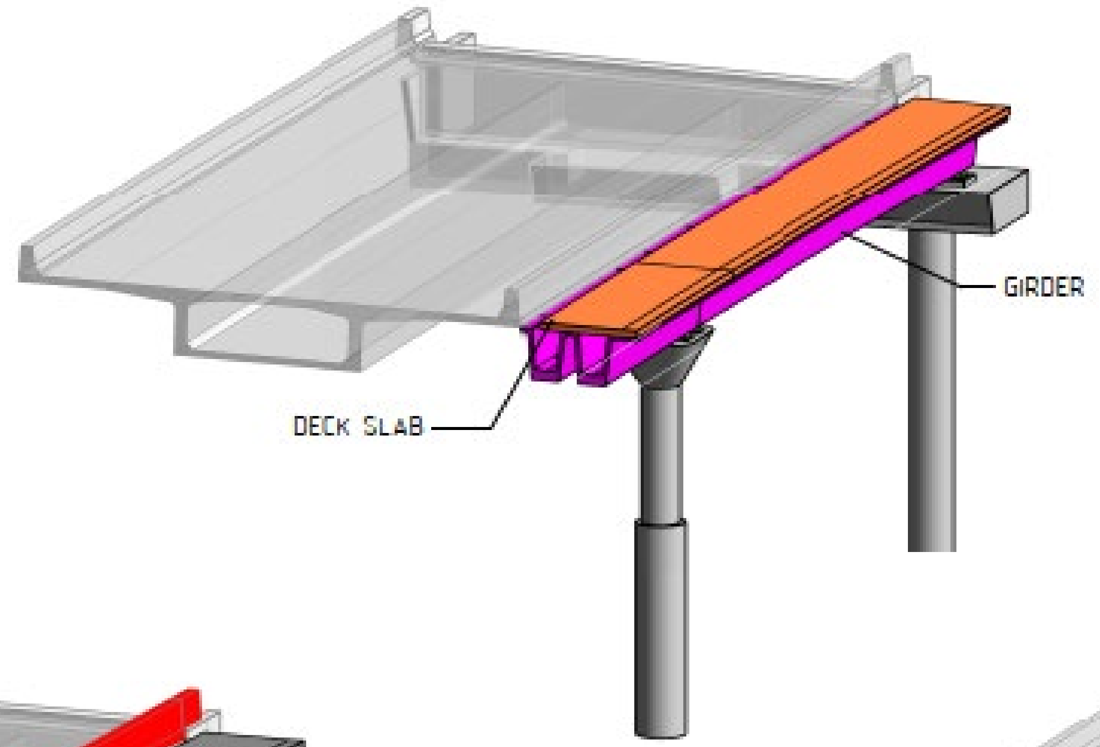


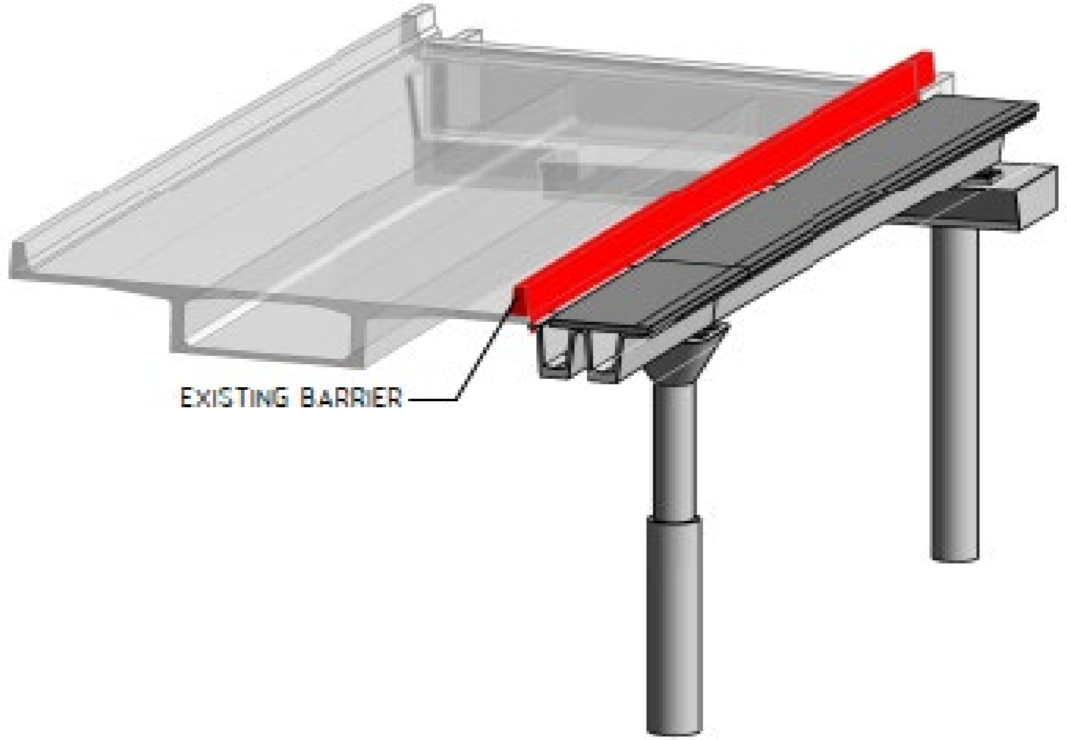
DESIGN RL (NORTH BOUND)	563.988	565.334	566.137	566.139	565.283	563.909
CHAINAGE (NORTH BOUND)	192.368	248.833	312.841	385.993	450.001	506.466

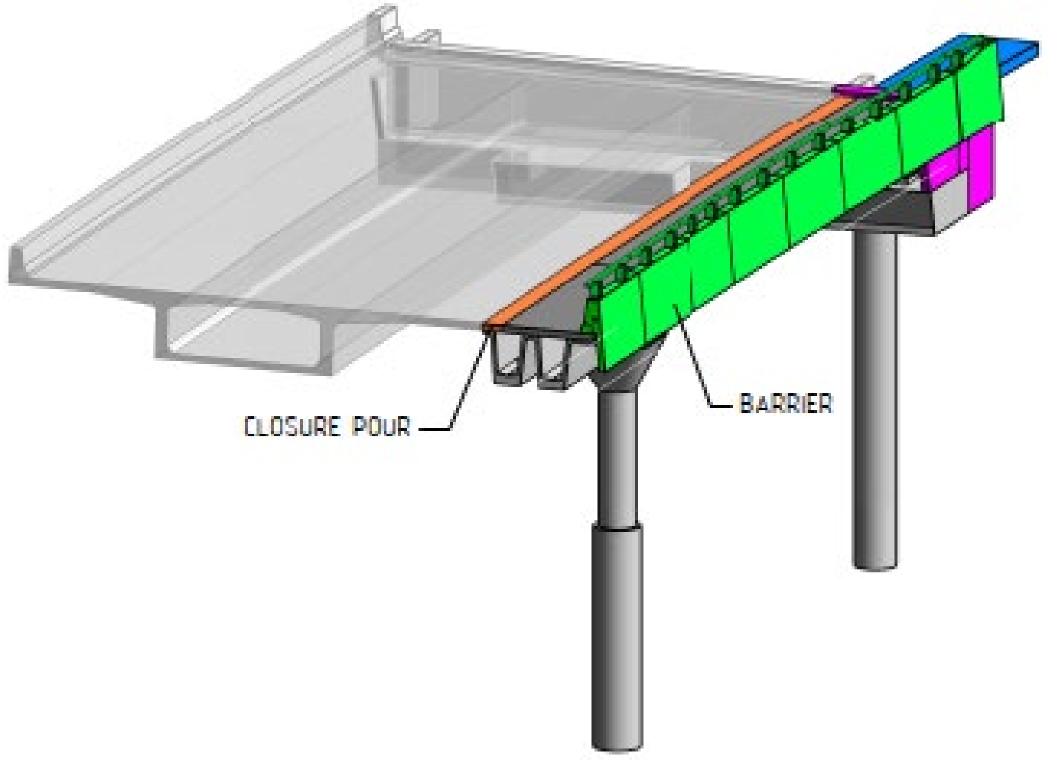
Bridge Widenings – An Example

Bridge Widening Overview









Case Study

- Existing twin viaducts comprising 22 spans, 700m long is being widened
- The existing bridge is a 2.0m deep boxed girder and in service over the last 20 years.
- The widening bridge comprises a pair of 1.5m pretensioned precast super-Ts.
- The existing and new piers could not be aligned due to constraints.

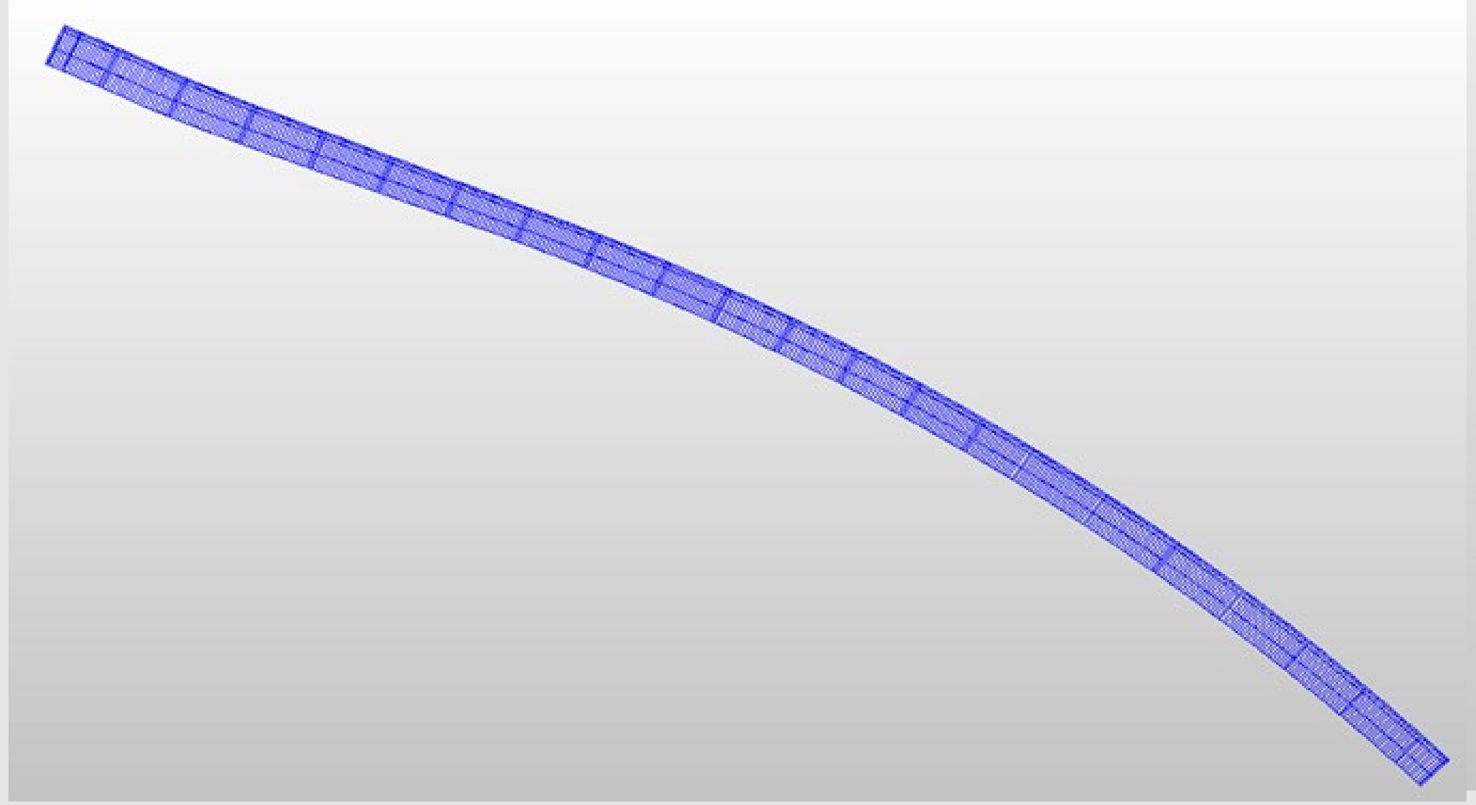
Widening Revit model

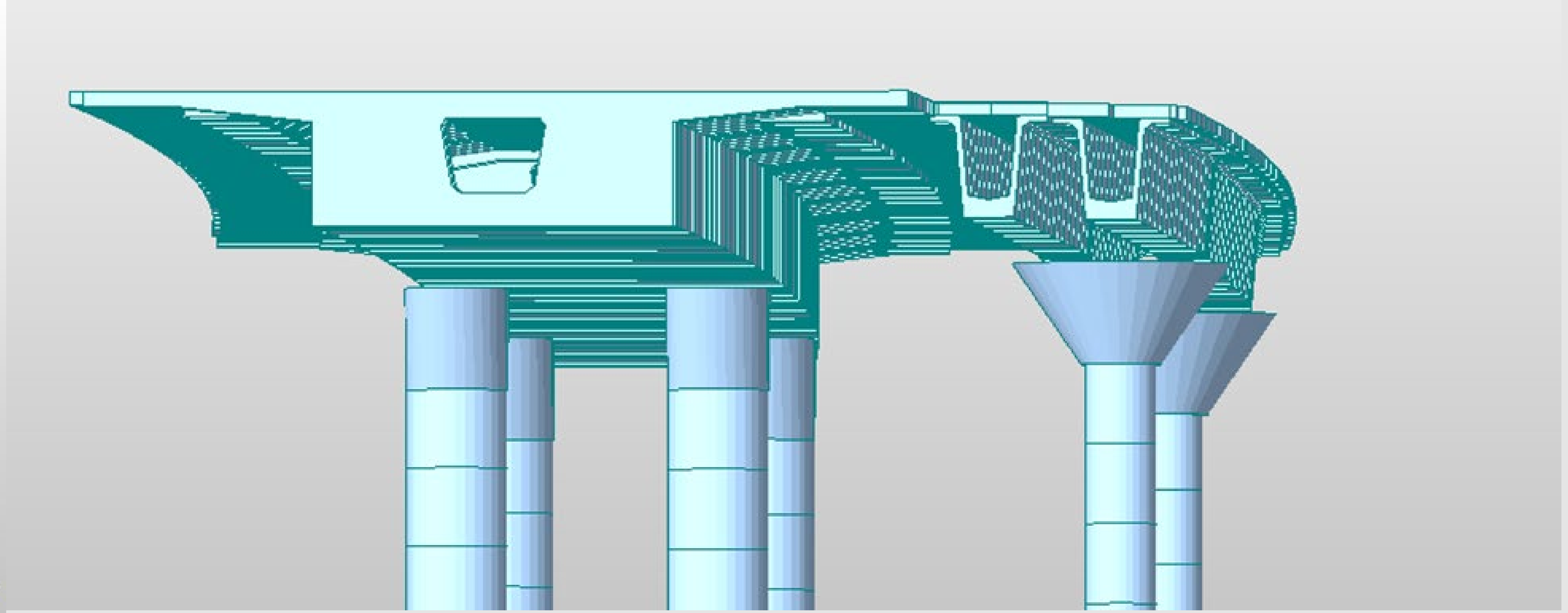
Case Study

The key challenges were identified

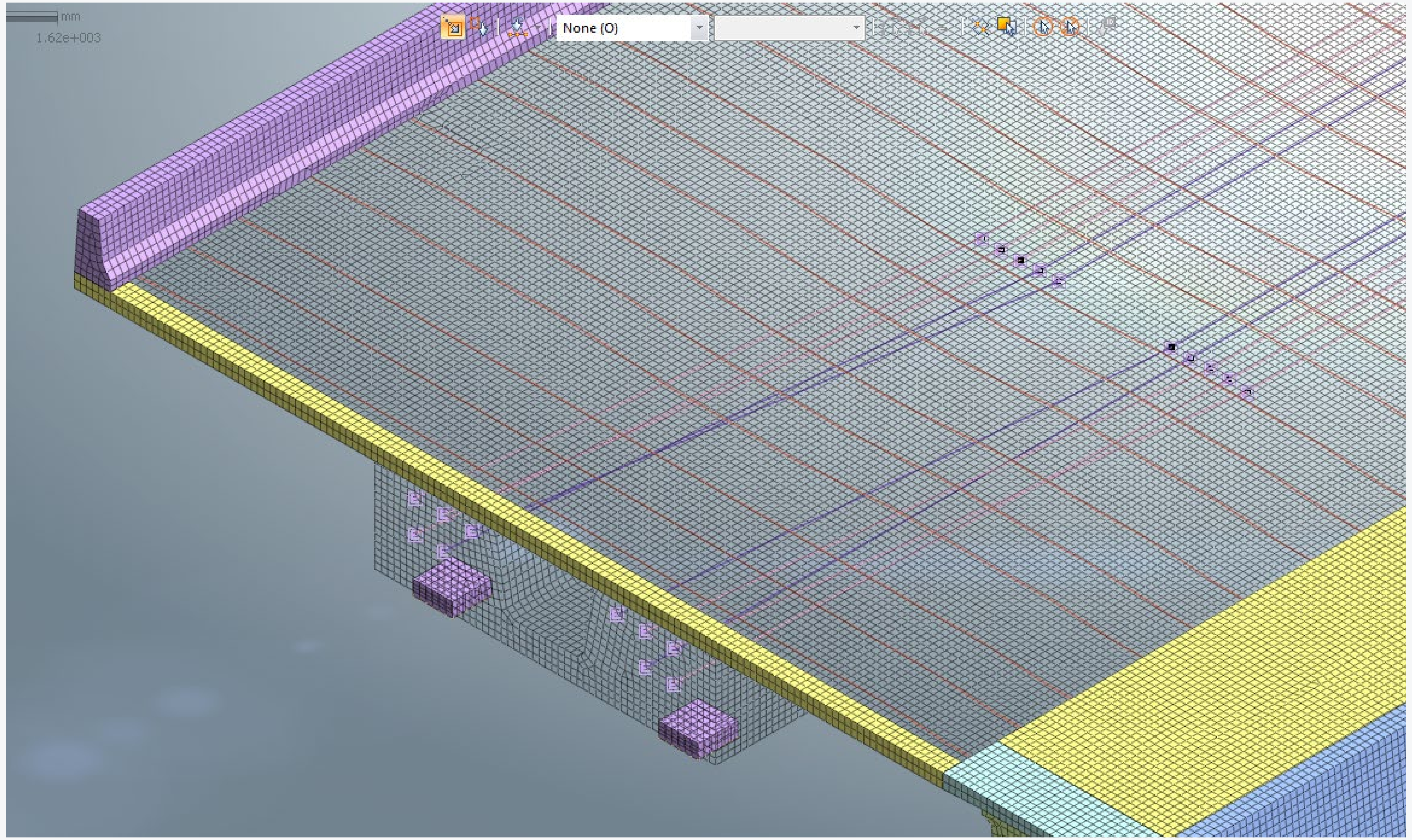
- Differential creep and shrinkage between the widening and the existing bridges
- The existing box was not designed for future widening as its cantilever bottom face is very lightly reinforced. The widening design must not adversely transfer load to the existing box.
- Transverse load transfer between the widening and the existing bridges. This behaviour was further complicated by the off-set piers.
- The existing bridge was designed for 3 design lanes of SM1600. New widening increases the bridge width and therefore the existing bridge can be subject to 4 design lanes.

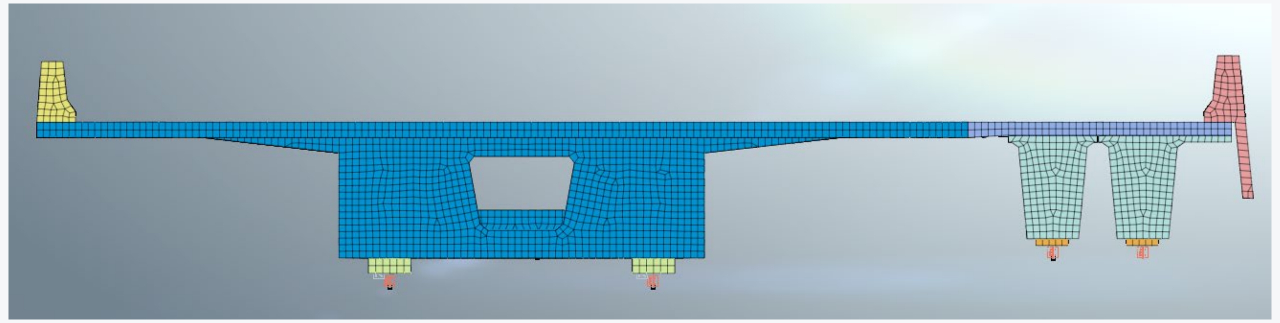
Case Study – MIDAS Model

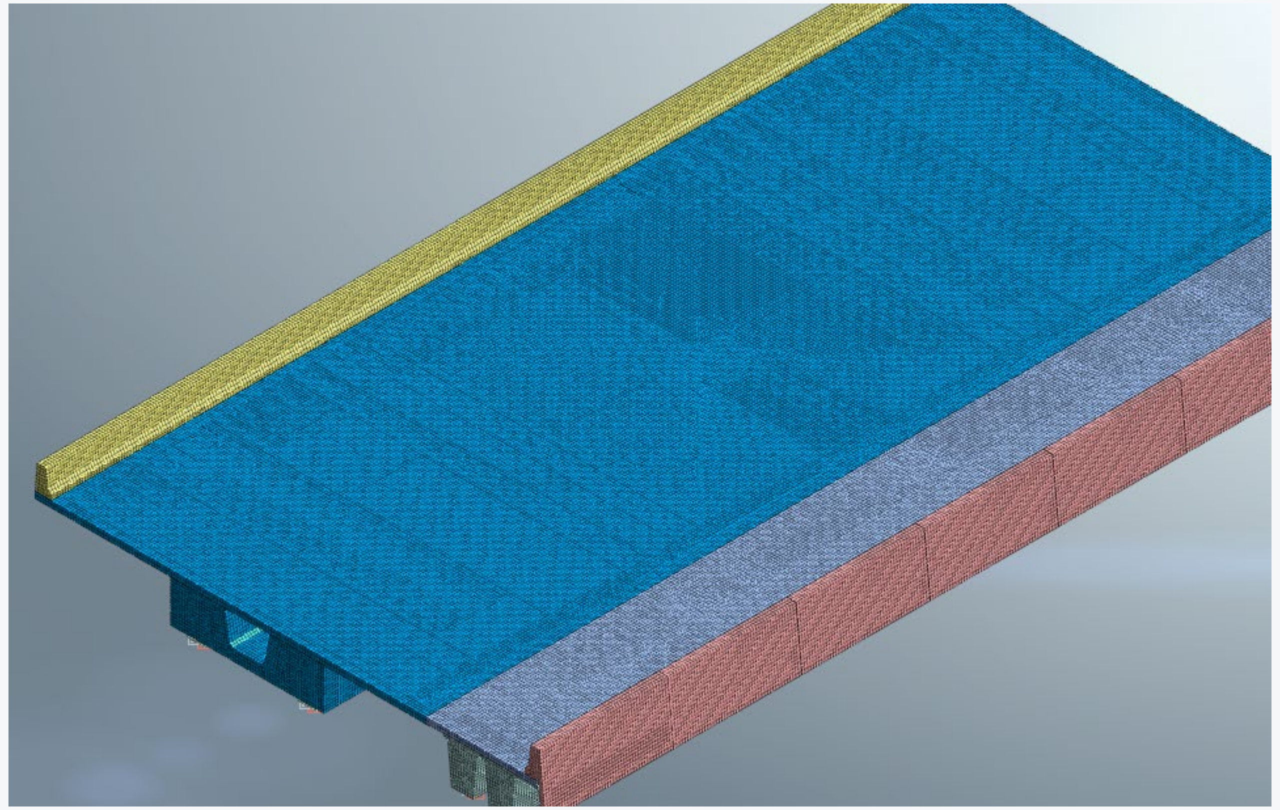




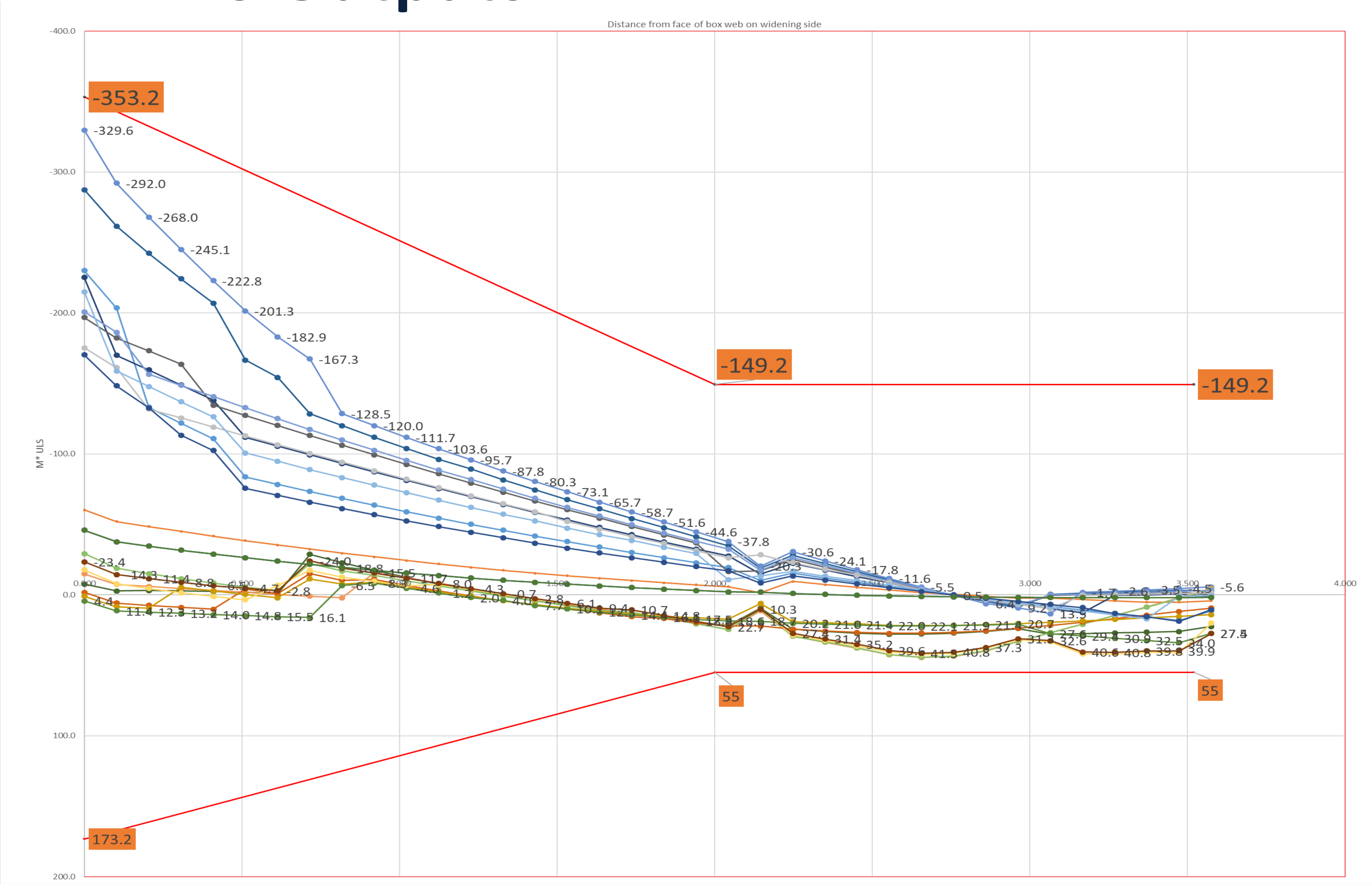
Case Study – MIDAS Model





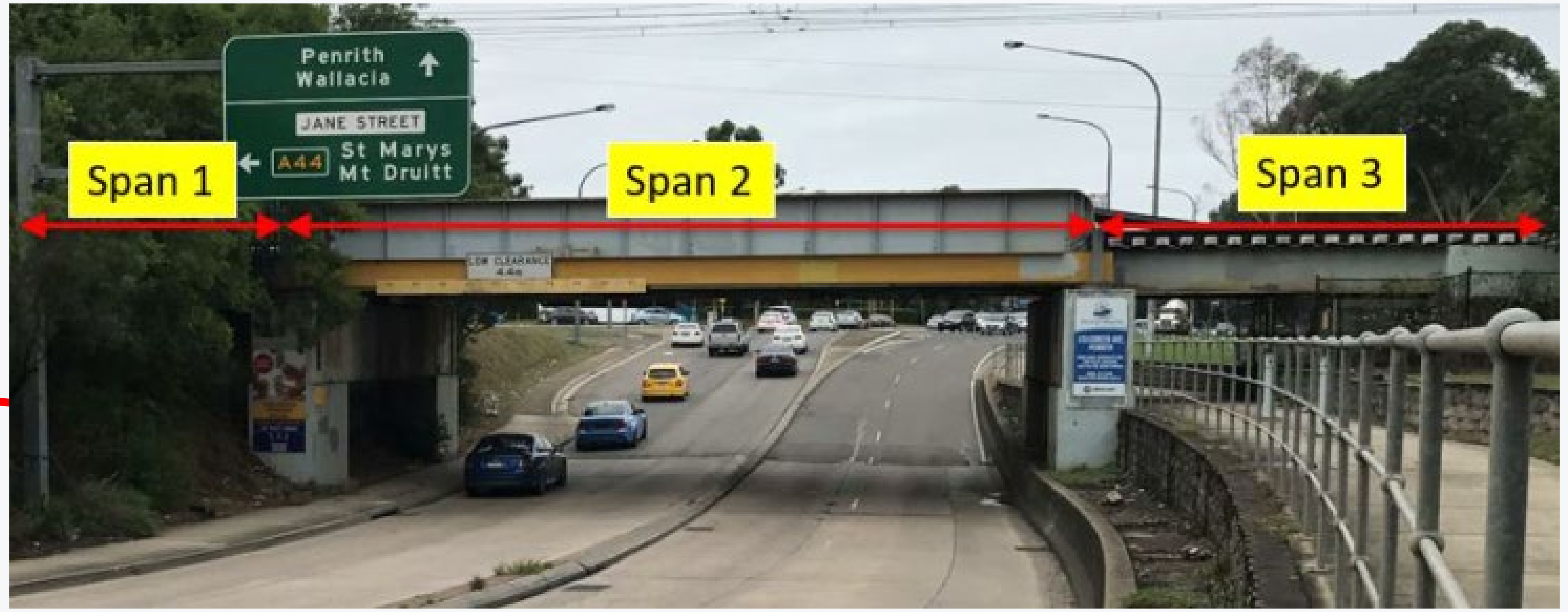


Case Study – MIDAS Outputs



Castlereagh Road Rail Bridge Replacement

Project Overview



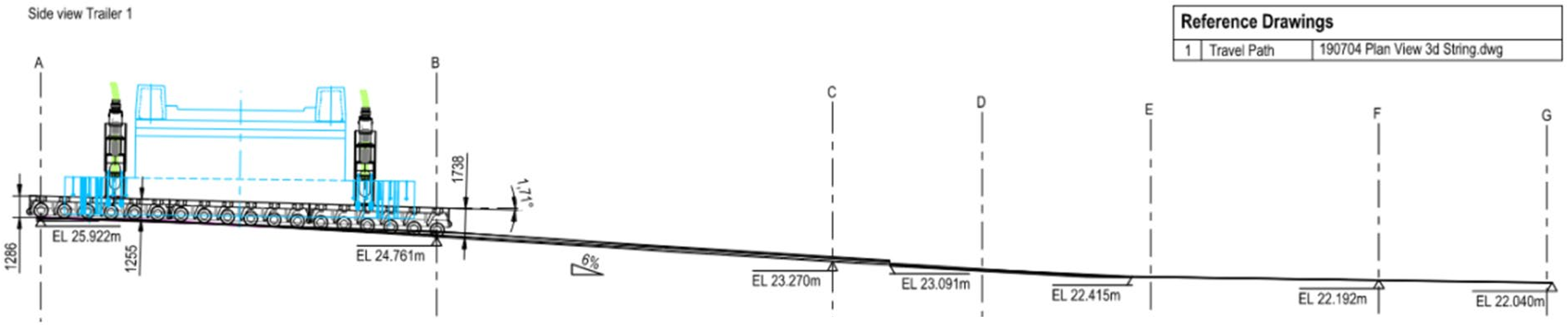
Project Overview

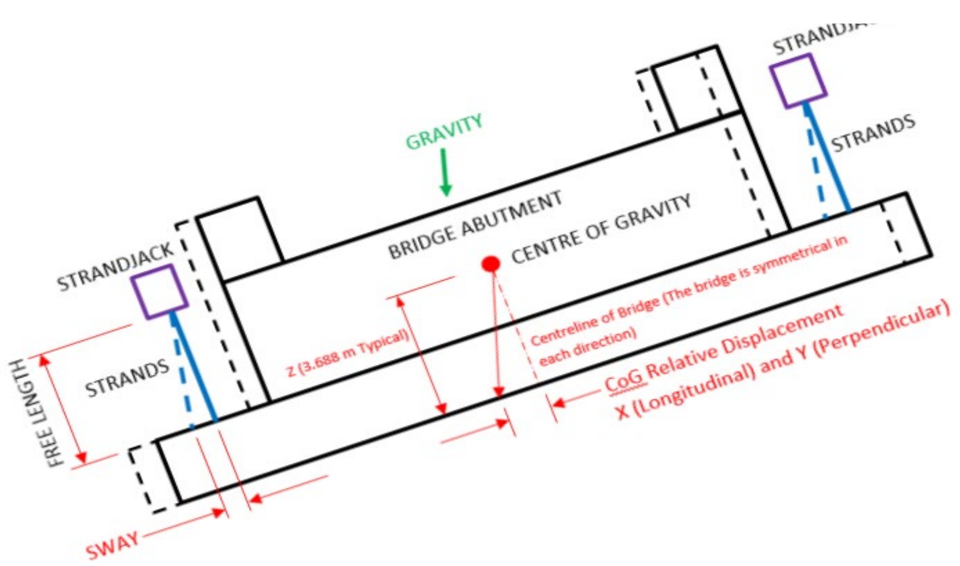
New integral bridge to accommodate the widening of Castlereagh Street.

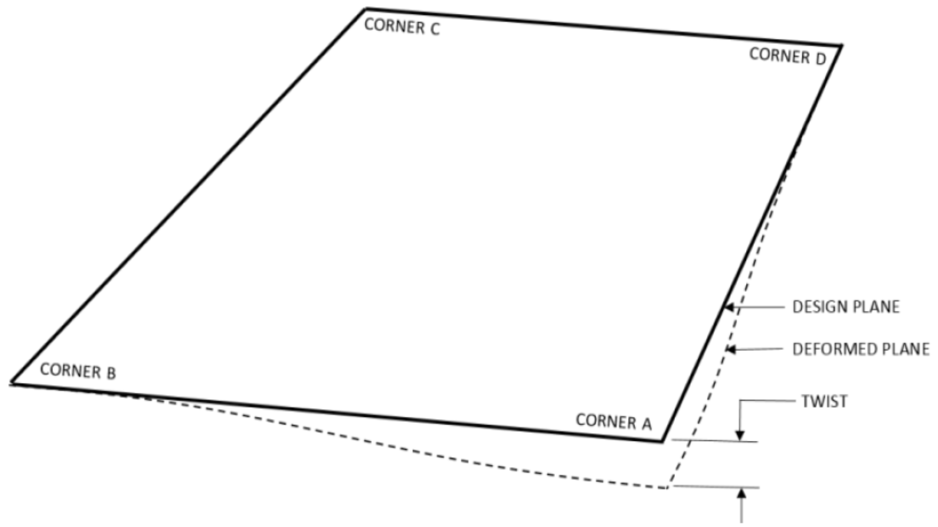
- Through trough girder arrangement with two PSC I-girders with in-situ haunches 39m span.
- Transverse deck slab comprises 450 mm precast units in composite with 150mm topping slab.
- Abutment walls supported on bored piles.

The entire bridge, including abutment walls, weighing 2500t was constructed off-site and then transported into position by Self-propelled Modular Transport system (SPMT).

SPMT design


Side view Trailer 1
Reference Drawings
1 Travel Path 190704 Plan View 3d String.dwg
A
B
C
D
E
F
G
1738
1.71°
1286
1255
EL 25.922m
EL 24.761m
6%
EL 23.270m
EL 23.091m
EL 22.415m
EL 22.192m
EL 22.040m

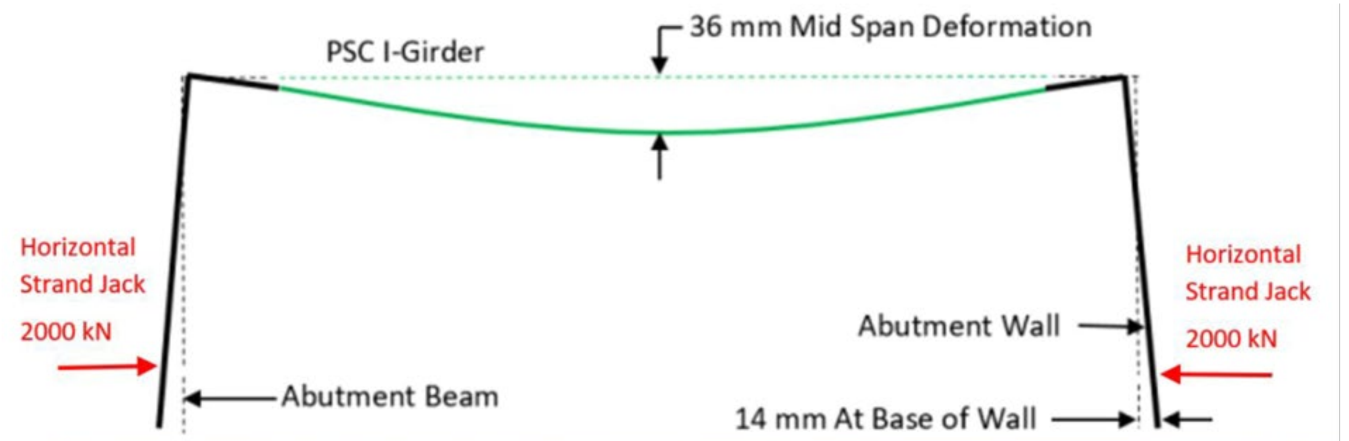

GRAVITY
BRIDGE ABUTMENT
CENTRE OF GRAVITY
STRANDJACK
STRANDS
STRANDS
FREE LENGTH
SWAY
Z (3.688 m Typical)
Centreline of Bridge (The bridge is symmetrical in each direction)
CoG Relative Displacement X (Longitudinal) and Y (Perpendicular)

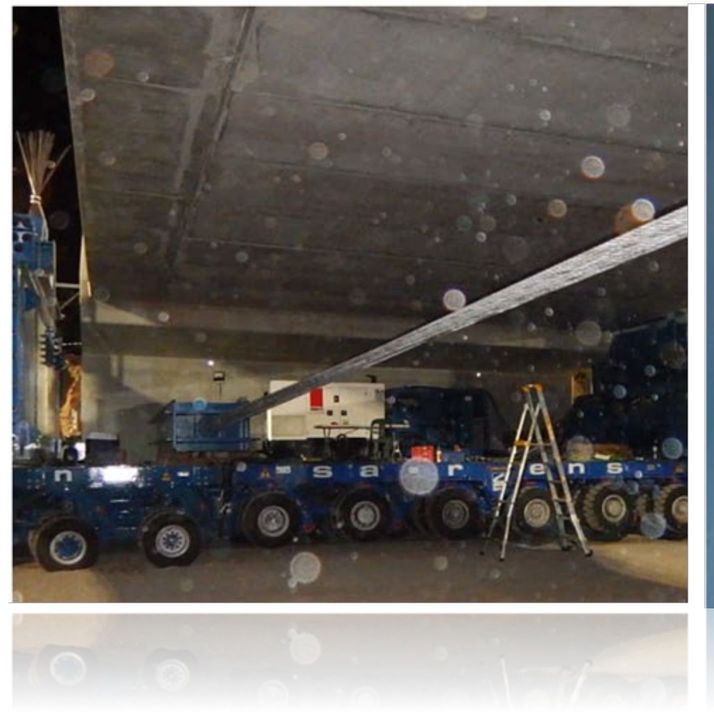

CORNER C
CORNER D
CORNER B
CORNER A
DESIGN PLANE
DEFORMED PLANE
TWIST

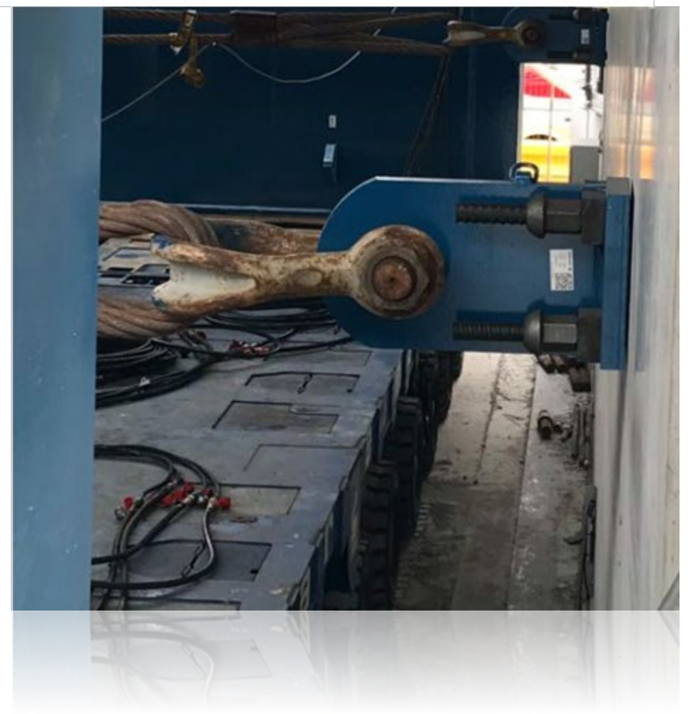
Structural Assessment and Design for SPMT Move

- The installation of the vertical stress bars to tie the bridge to its foundation required perfect vertical alignment of the recess holes.

- To compensate for the anticipated 14mm outward deflection of the bridge abutment wall, a pre-load of 2000kN was assessed to hold the abutment walls in place. This force was applied through two horizontal strand jacks, 1000kN working load each to counteract the outward movements

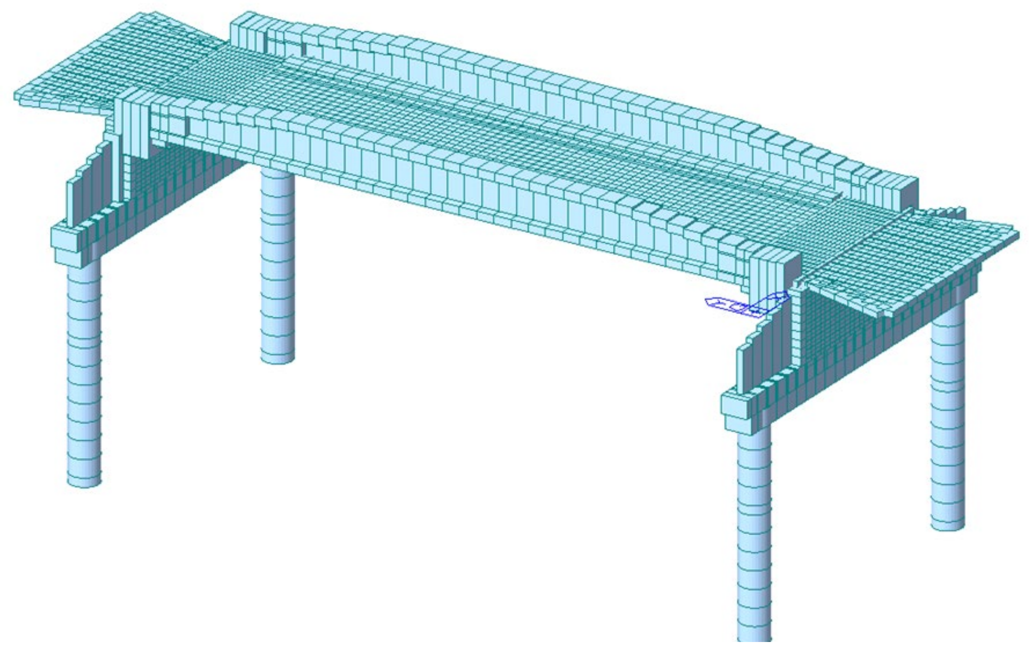


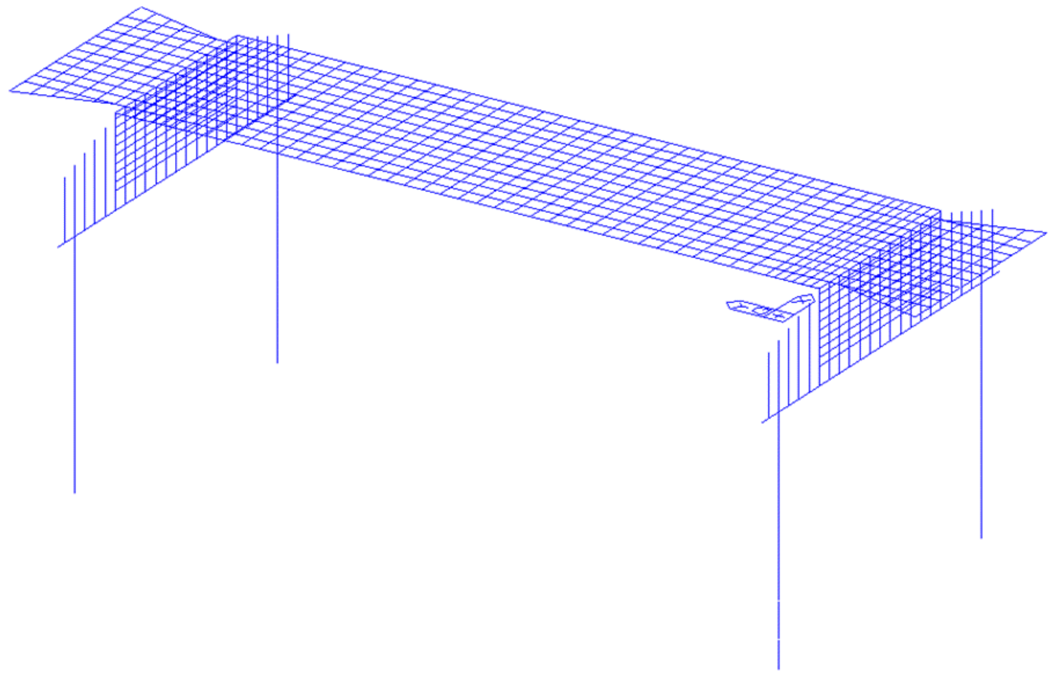




Midas Model and Outcomes

- Midas was adopted as a software of choice to undertake all the structural analysis and part design for the permanent works and construction engineering of the SPMT move.
- Midas had a readily available suite of various bridge loading functions in accordance with the Australian Bridge Design Code AS5100, which made the modelling very time efficient over other packages
- The bridge replacement, including the removal of the existing bridge was successfully implemented over the 5-day track possession during Christmas 2019.





Midas Model and Outcomes

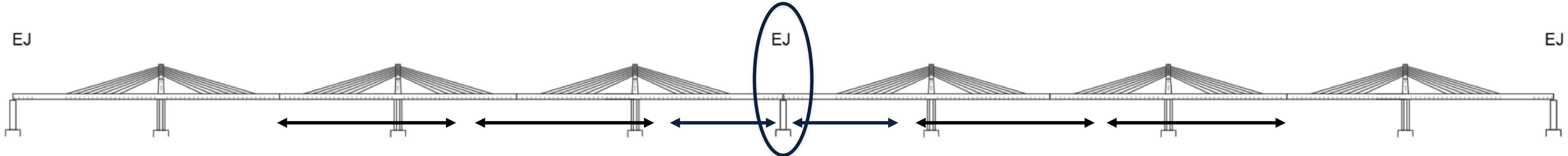
Palasbari Bridge, India

Visualisations

Bridge Form

OPTION 1: Conventional Extradosed Form

- Back span length is 50 to 60 % of the main span length
- Expansion joint located at piers



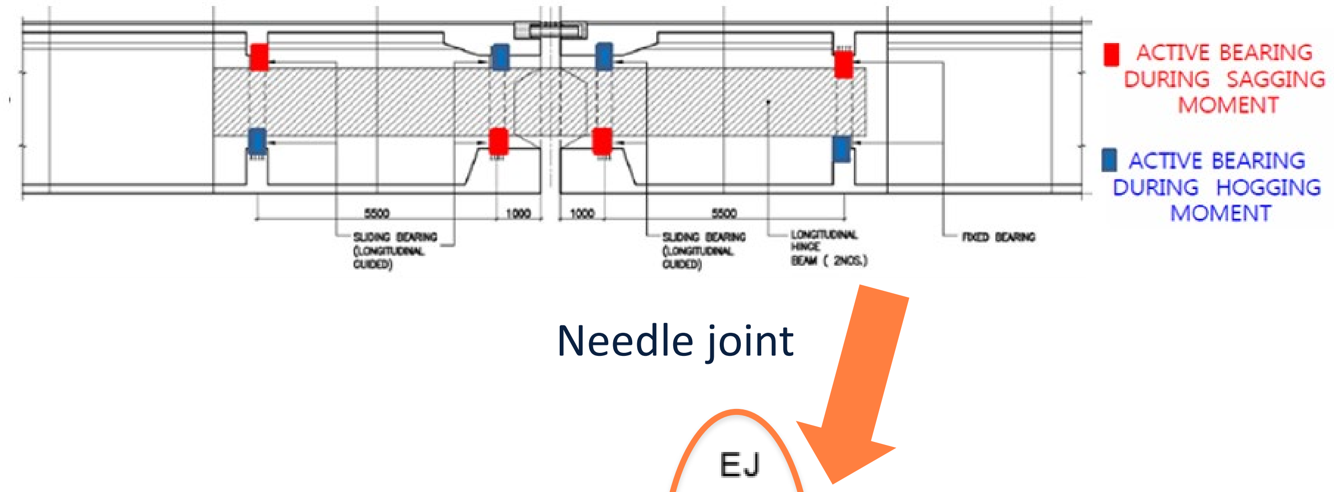
OPTION 1: 0.625 BACK-SPAN - MAIN SPAN RATIO. EXPANSION JOINTS AT PIER POSITIONS.

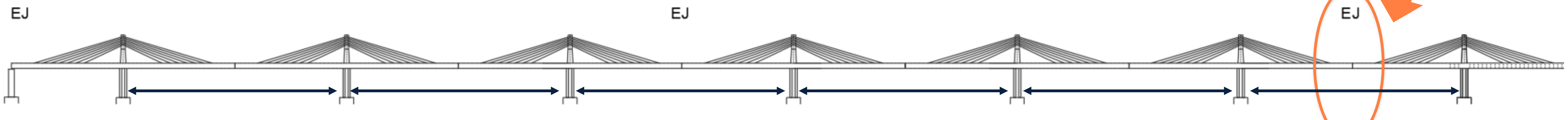
Bridge Form	Advantages	Disadvantages
Option 1 – Conventional Extradosed Form	• Follows a conventional extradosed bridge form • Joints located at piers are accessible for maintenance	• Discontinuity in visual appearance from piers at expansion joint locations. • Intermediate piers required to support backspans • More piers results in increased construction duration

Bridge Form

OPTION 2: Needle Beams at Midspan Expansion Joints

- All span lengths are equal – continuous appearance
- Expansion joint located at midspan using needle joints





OPTION 2: 0.5 BACK-SPAN - MAIN SPAN RATIO. NEEDLE JOINTS AT MIDSPAN.

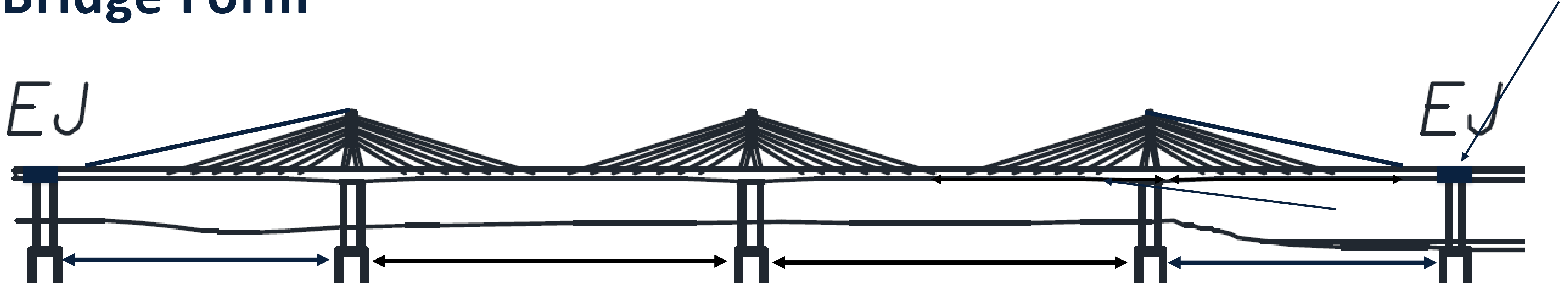
Bridge Form	Advantages	Disadvantages
Option 2	• Continuous superstructure and substructure appearance • Follows a conventional extradosed bridge form • Less piers required	• Needle beams are impractical and difficult to install - Increases construction complexity • Needle beams are difficult to maintain • Needles beams are impossible to replace • Contractors have moved away from using needle beams of multi-span bridges

Bridge Form

OPTION 3: Increased Backspan Length

- Back span length can be 80 % of the main span length – resulting in a more uniform appearance
- Expansion Joint located at piers

Bridge Form



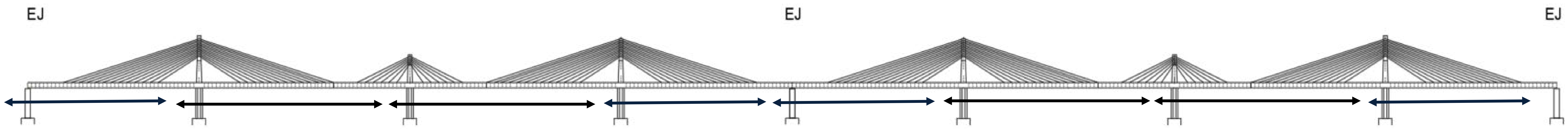
Bridge Form	Advantages	Disadvantages
Option 3 – Increased Back Span Length	• Continuous and uniform substructure appearance • More economical in terms of number of piers required • Joints located at piers are accessible for maintenance	• Backspan length is greater than typical extradosed bridge forms and may require temporary support during construction • Overly long end spans unsupported by cables have unavoidable girder behaviour which drives girder depth and stay system design – Variable depth girder will likely be required

Bridge Form

OPTION 4: Increased Backspan Length with varying Pylon Heights and additional cables

- Back span length can be 80 % of the main span length – more uniform appearance
- Pylon height increased and additional stays added to support longer end spans
- Expansion joint located at piers
- Unique appearance

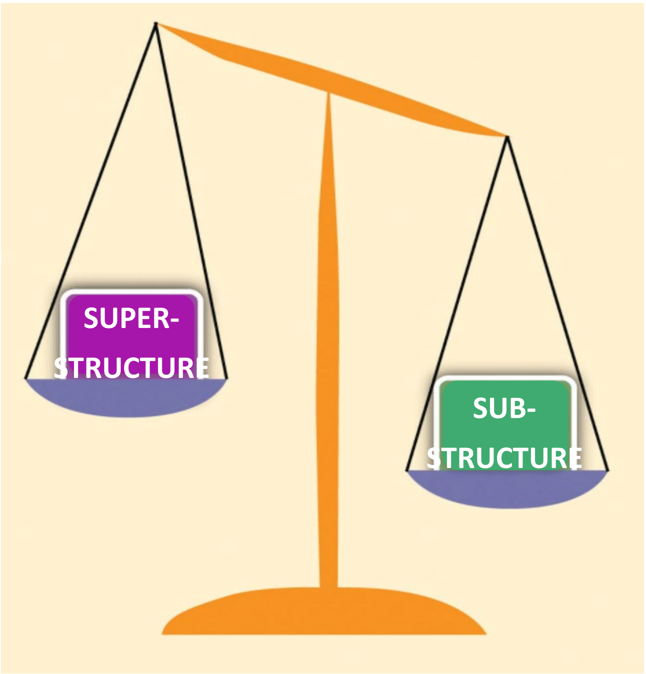
Bridge Form

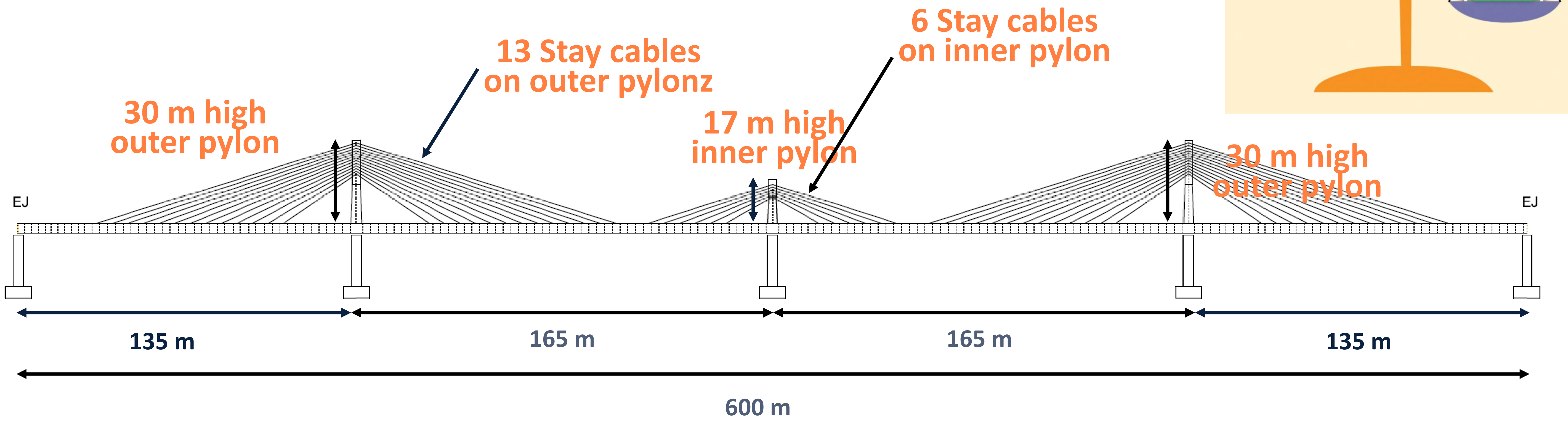


Bridge Form	Advantages	Disadvantages
Option 4 – Alternating Pylon Heights	• Unique appearance in superstructure form • Continuous substructure appearance • More economical in terms of number of piers required • Joints located at piers are accessible for maintenance • Taller pylon results in more efficient deck and stay cable system design	• Taller pylons and longer stay cables required for outer pylons

Preferred Structure

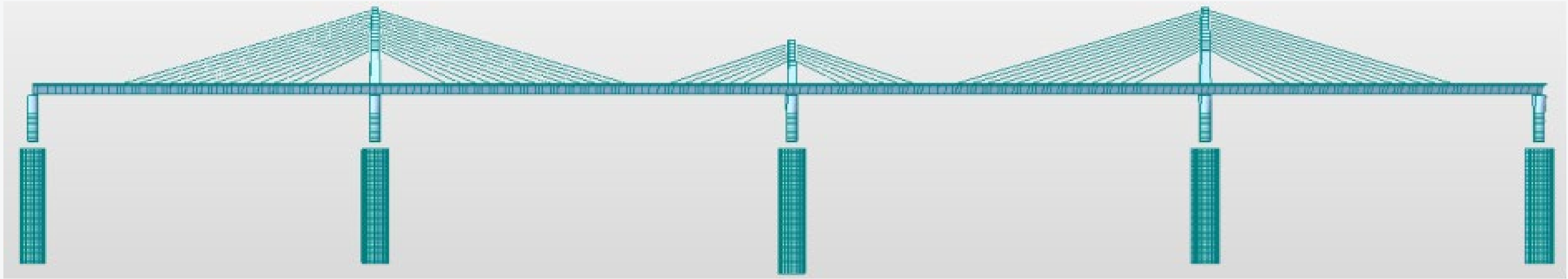
- **Bridge Type** – Multi-span extradosed bridge
- **Bridge Form** – Option 4: Increased Backspan Length with varying Pylon Heights and additional cables
- **Main Span Length** – 165 m

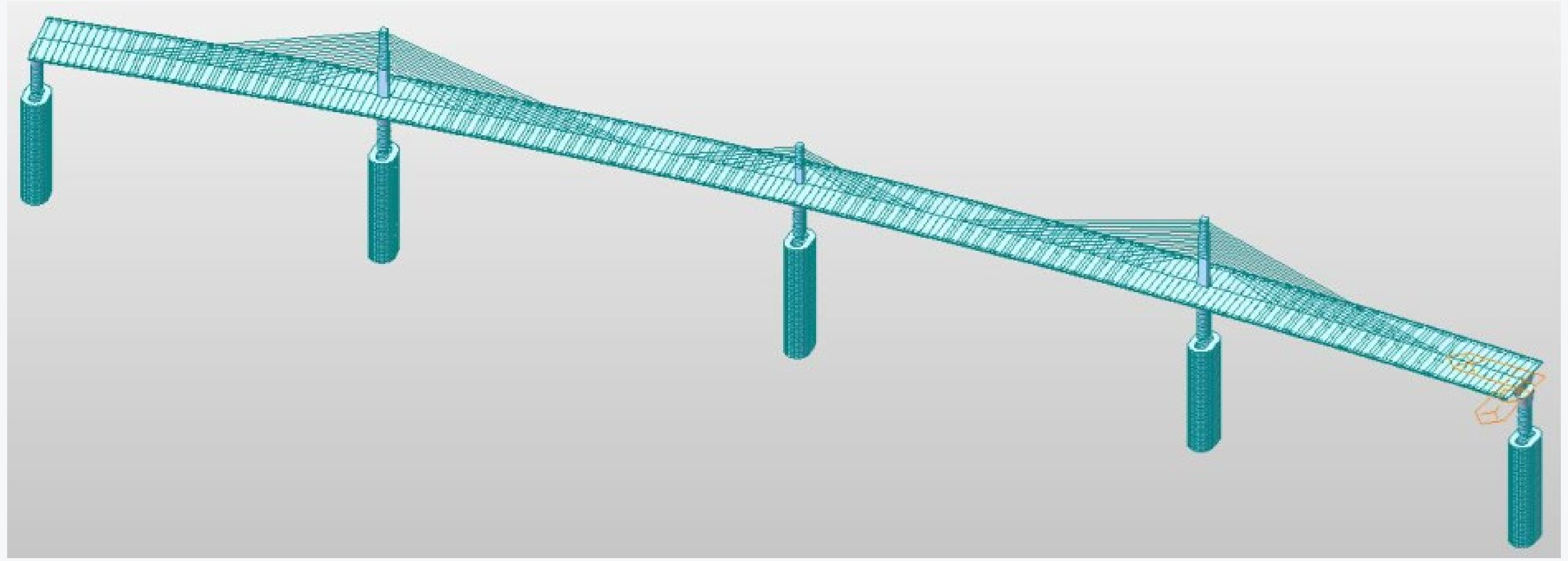




Midas Model and Outcomes

- Midas was used to develop the bridge model including all construction stages
- Key design aspects such as cable pre-stressing forces and time history analyses and ground responses were determined using the developed Midas model.
- Optioneering study was facilitated by parametric inputs to allow easy adaption of the model changes.





Conclusions

- SMEC has successfully been deploying Midas as an efficient tool to enhance its bridge design capability and to achieve success on past and current projects.
- Midas is selected over several other software as a standard tool due to its following advantages
  - Specifically developed for bridge design and analysis, including a readily available suite of features compatible with the Australian Bridge Design Standard AS5100.
  - Readily compatible interfaces between its modules and other bridge design documentation software. This enables high efficiency in transferring information between its modules and with other software package.
  - Excellent post –installation services via extensive roadshows, technical support seminars and technical support resources

Where we operate

120+ Offices

40+ Countries

16,500+ Employees

Australia, New Zealand & Pacific Islands
Australia
New Zealand
Fiji
Papua New Guinea
Solomon Islands

Africa
Ethiopia
Kenya
Tanzania
South Africa
Namibia

North America
Canada
US (Seattle)

North Asia
China

South America
Chile

South & Central Asia
Afghanistan
Bangladesh
Georgia
India
Kazakhstan
Nepal
Pakistan
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Tajikistan
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Brunei
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Malaysia
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Myanmar
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London

SMEC
Member of the Surbana Jurong Group

Thank You

Kenny Luu – Manager, Structures ANZ
14 November 2023, Seoul, Korea