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NEW ASHTON ARCH

Presented by AECOM SA
June 2021

WESTERN CAPE GOVERNMENT

BACKGROUND

DESIGN AND CONSTRUCTION CONSIDERATIONS

CONSTRUCTION OF TEMPORARY AND PERMANENT WORKS

CONSTRUCTION CHALLENGES

TRANSVERSE LAUNCHING

ACKNOWLEDGEMENTS

WESTERN CAPE GOVERNMENT

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BACKGROUND

Strategic road link

- Important local and national route
- Main link between Ashton and Montagu
- Important Tourism Route
- Scenic and historic considerations

Why upgrade Route R60/62?

Flooding

Various floods in the area leading to damage and related road closures leading to geometric, pavement and structural improvements:

- To enhance flood resistance
- Improve flood capacity at critical locations

Flooding

- Hydraulically inefficient
- Recurring floods resulting in damages
- Debris build-up


24 3 2003


24 3 2003


24 3 2003

Overtopping of existing bridge

Debris build-up

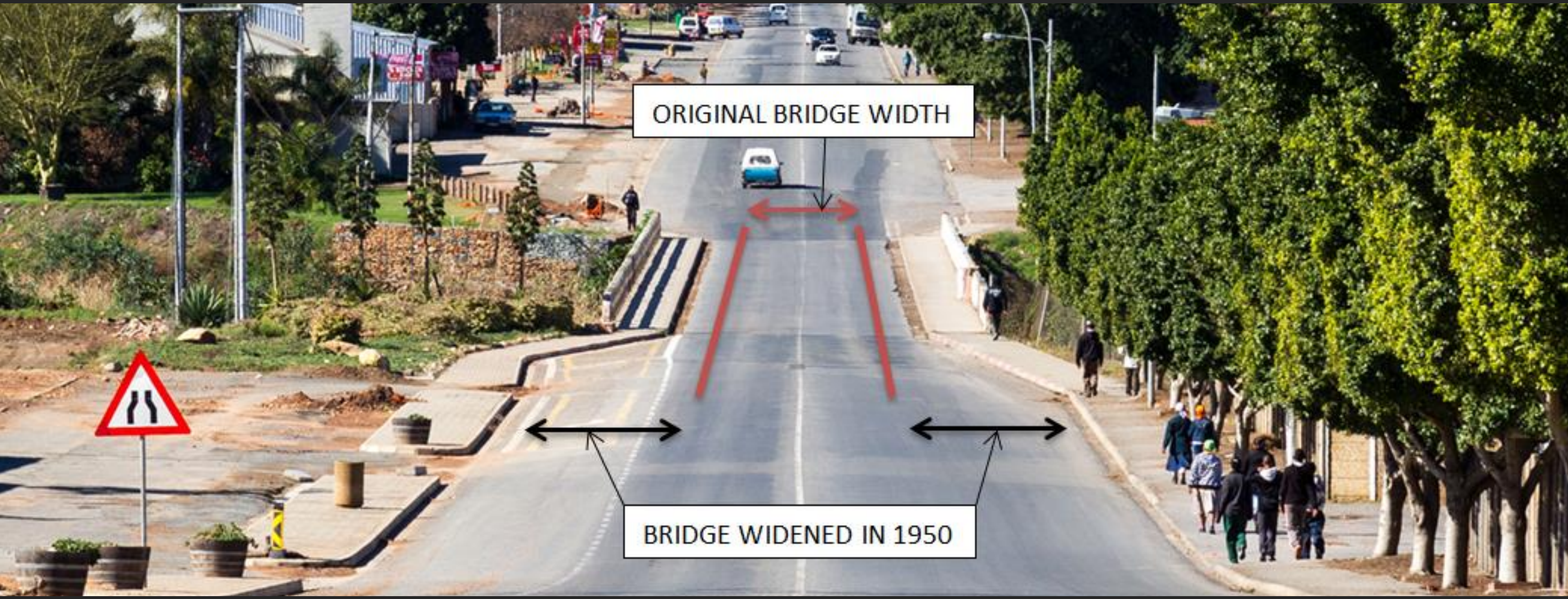
Damage and debris build-up

Hydraulic Capacity

- Arched deck soffit hydraulically inefficient
- Pier in river obstructs flow and allows for debris build-up
- Overtops during large floods event

Existing Bridge Configuration

- On R60 which is an important link between N1 and N2
- Built in 1930 and widened in 1950
- Negative impact on traffic flow



Existing Bridge Configuration

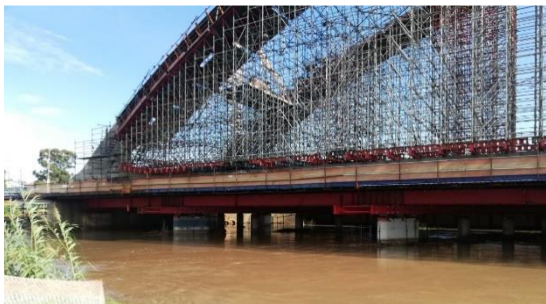
- Built in 1930’s [single lane]
- Substantially widened in 1950 [(x2) 3,35m lanes + 1,80m sidewalks]
- Total Length of bridge ± 95m
- Angle of Skew 50°
- Road level varies between 5m to 8m above NGL

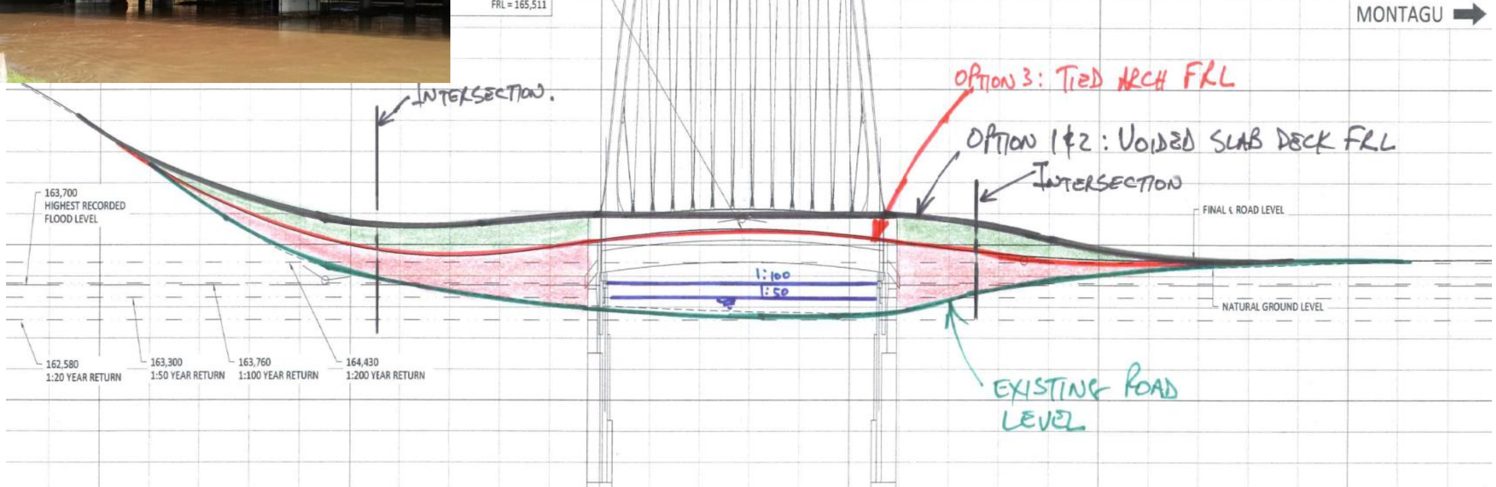
Option 1, 2 & 4: Voided Slab or Precast Beams

- Deck depth = approx. 1,50m
- Raise existing FRL with 3,00m to achieve min freeboard
- 4 Piers in river = debris build-up
- Higher approach fills complicates intersections

Option 3: Tied Arch Bridge

- Deck depth = 1,00m
- Raise existing FRL with 2,50m to achieve min freeboard
- No piers in river = no debris build-up



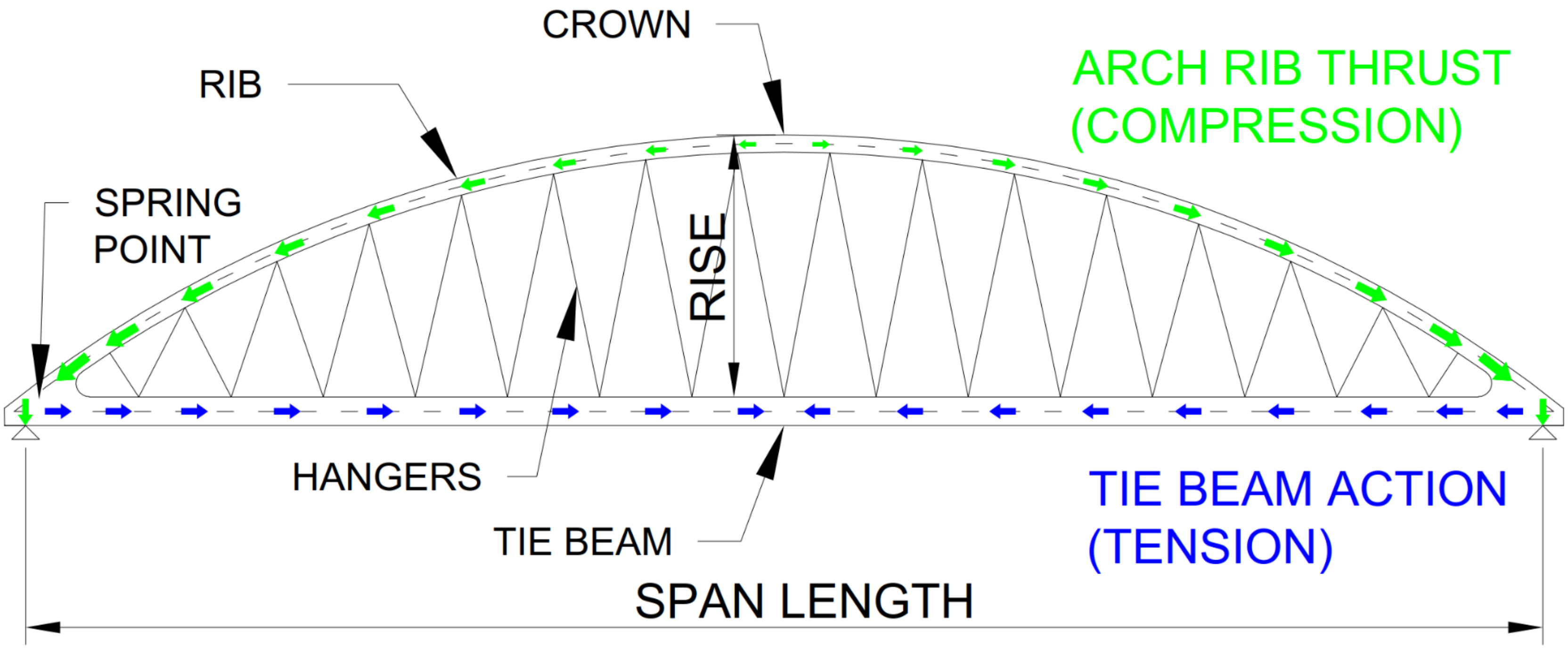


Options considered

Key Design Considerations	Voided Slab Deck with Temporary Bypass	Voided Slab Deck built in Half Widths	Single span Tied Arch Launched transversely	Precast Beams a) Temp Bypass b) Half widths
Hydraulic efficiency	✓	✓	✓✓	✓, ✓
Construction flood risk	✗	✓	✓	✗, ✗
Geometric Alignment	✓	✗	✓✓	✓, ✓
Traffic Accommodation	✓✓	✗	✓✓	✓✓, ✗
Aesthetics	✓	✓	✓✓	✗, ✗
Constructability	✓✓	✗	✓	✓, ✗
Ratio: Construction costs	1.15	1.0	1.35	1.20
Ratio: Construction + indirect costs	1.20	1.0	1.10	1.25

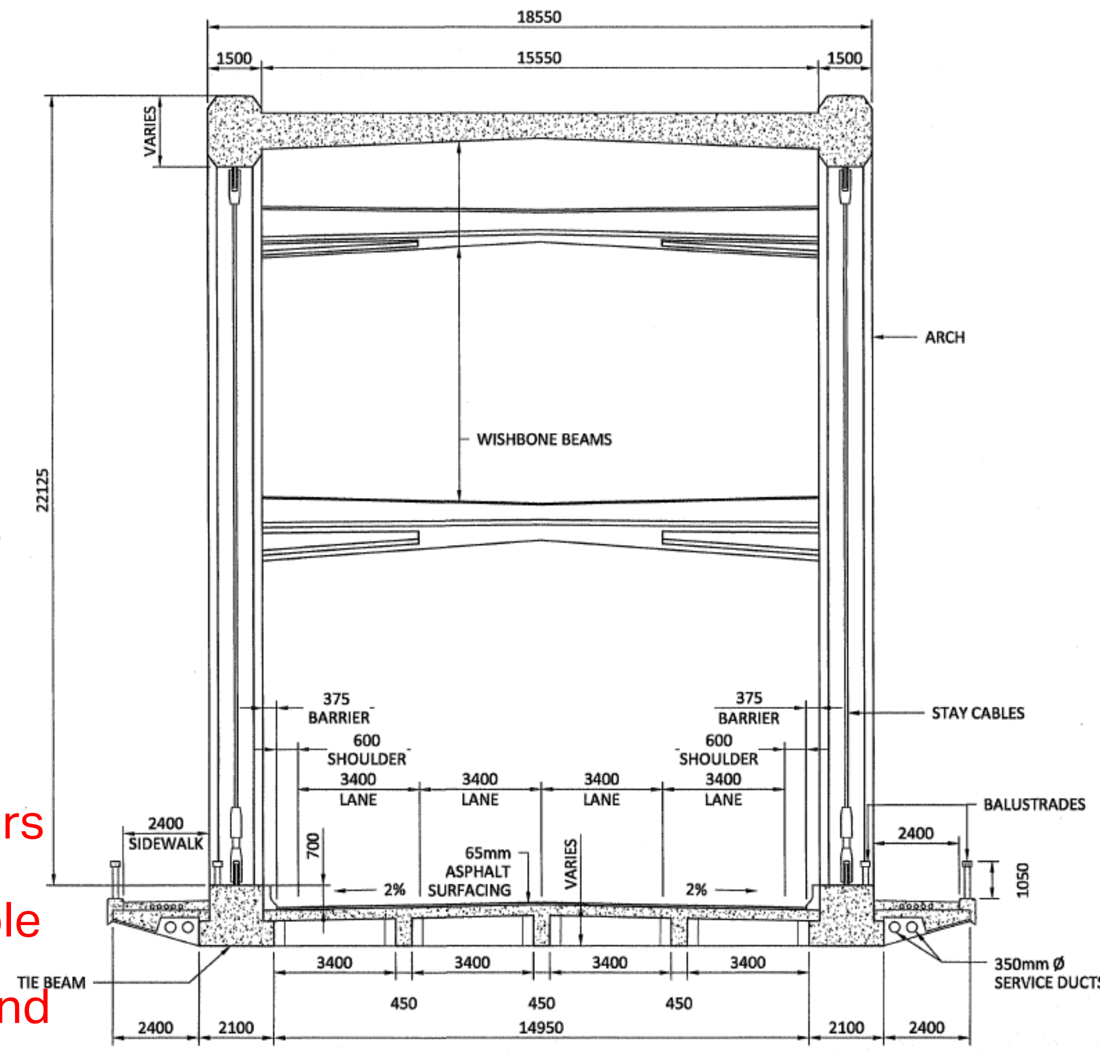
Final Concrete Tied Arch Configuration

General details of Ashton Arch



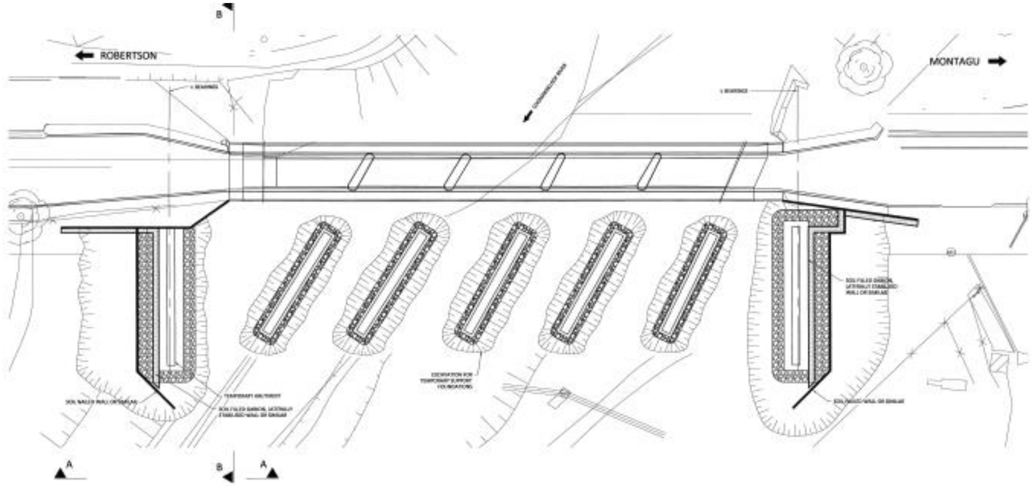
General details of Ashton Arch

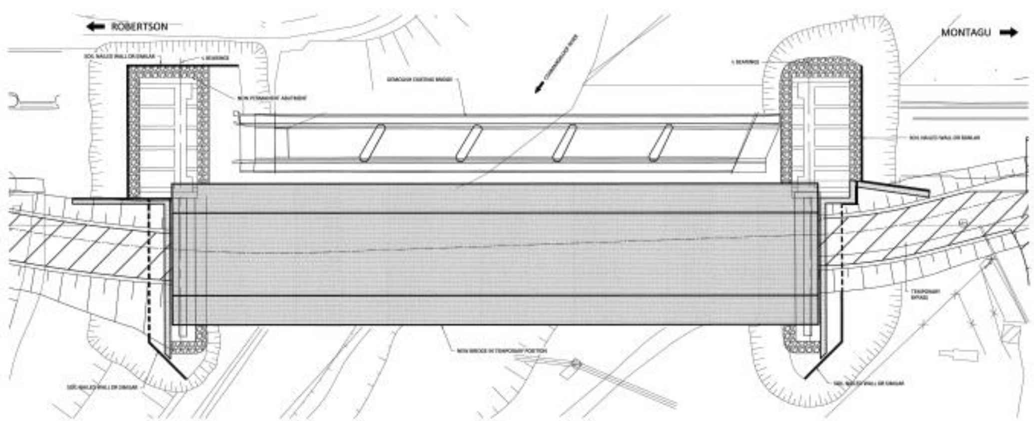
- Single tied concrete arch
- 110m span
- 4 x 3.4m traffic lanes
- 2 x 2.4 m side walks
- 22m arch rise
- 5 x 15.6m transverse wish bones
- Twin post-tensioned arch ties
- Post tensioned deck grillage
- 48 x fully locked coil cable hangers
- hangers connected with adjustable cast iron fork sockets & compound welded steel anchors



Transverse Launching Concept

TEMPORARY WORKS CONCEPT (TENDER STAGE)





DESIGN & CONSTRUCTION CONSIDERATIONS

Structural form and bridge aesthetics

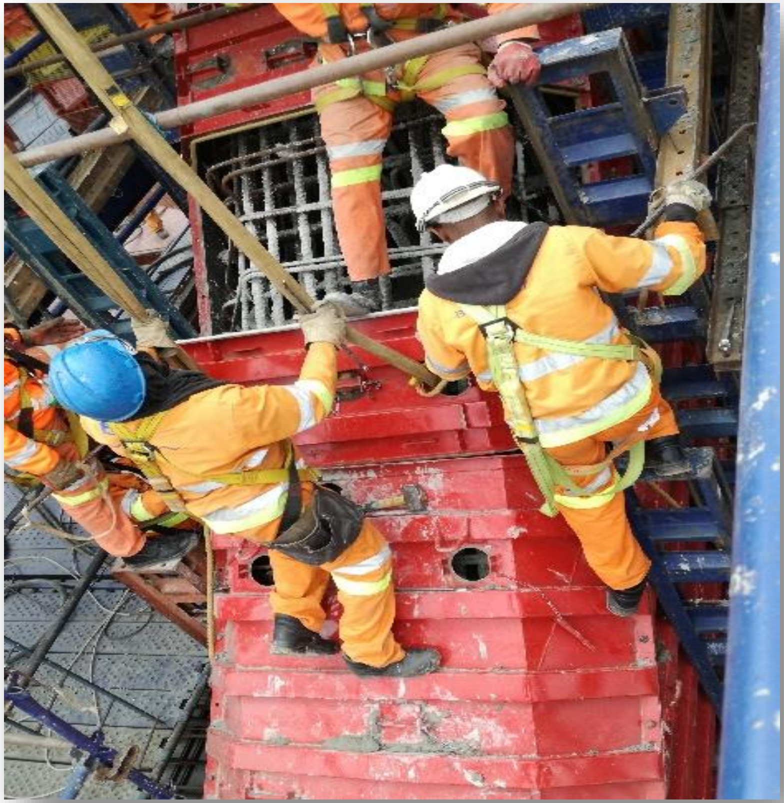
- Attention was paid to the historical significance of existing multiple-span arch bridge
- Major benefit of the arch is ability to span over the entire river and consequently improves the hydraulic efficiency, specifically due to the large skew angle
- A tied-arch bridge is particularly suitable for this topographic location, since it suspends the roadway and does not require propped arch founding conditions
- V-hanger-configuration was adopted in preference to the vertical hanger orientation, since it provides an aesthetic advantage
- Aesthetically, the slender tied arch design is appropriate since the depth of the proposed roadway above the riverbed with a visually appealing light deck.
- The tied-arch form expresses a visualisation of flowing of forces with light hangers and slender members displaying a transparency accentuated by the surrounding mountains

Concrete as the primary construction material

- Primary load transfer mechanism of the arch rib is compression
- Due to the complex nature of the flow of forces within the spring point, particular attention to modelling and analysing this element was paid during the detail design
- In terms of concrete volumes cast, the four spring points are massive elements, requiring management of thermal performance (heat of hydration) of the concrete and associated cumulative strains
- Particular concrete placement methodology was adopted to exercise due care in the construction of the tie points, using pre-inserted temporary steel tubes (160mm dia)
- A specially developed, high mobility 50/13 pumpable, concrete mix was designed for casting the tie points.
- Thermal performance was predicted according to Ciria C660 ‘Early-age thermal cracking control of concrete.
- Additionally, the peak temperature within these massive elements were monitored via embedded Giatec SmartRock sensors

Concrete as the primary construction material

Steel tube concrete pour access provided through congested reinforcement



Top/inclined shutters introduced incrementally as pour progressed (temporary inspection holes visible

Structural modelling for design and construction

- Structure was modelled locally using Bentley's RM Bridge and internal design review conducted by the AECOM's UK complex bridge specialist team using SOFISTIK
- The state-of-the-art analysis software packages modelled construction stage and in-service analysis for design.
- Models were updated with concrete material parameters, determined from laboratory testing allowing accurate simulation of stage & time-dependant material behaviour
- Updated models were calibrated for determination of the following with continuous backward analysis comparisons of actual results during construction:
  - Hanger length determination,
  - Hanger force distribution optimisation,
  - Pre-camber requirements & influence of temporary works displacements,
  - Movement capacities of (temporary and permanent) & expansion joints

CONSTRUCTION OF TEMPORARY AND PERMANENT WORKS

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Temporary Works

- Temporary abutment
- Caisson foundations
- Temporary Columns
- Lateral support

Temporary works

Deck False Work

- Transverse steel girders
- Sand jacks
- Longitudinal steel girders

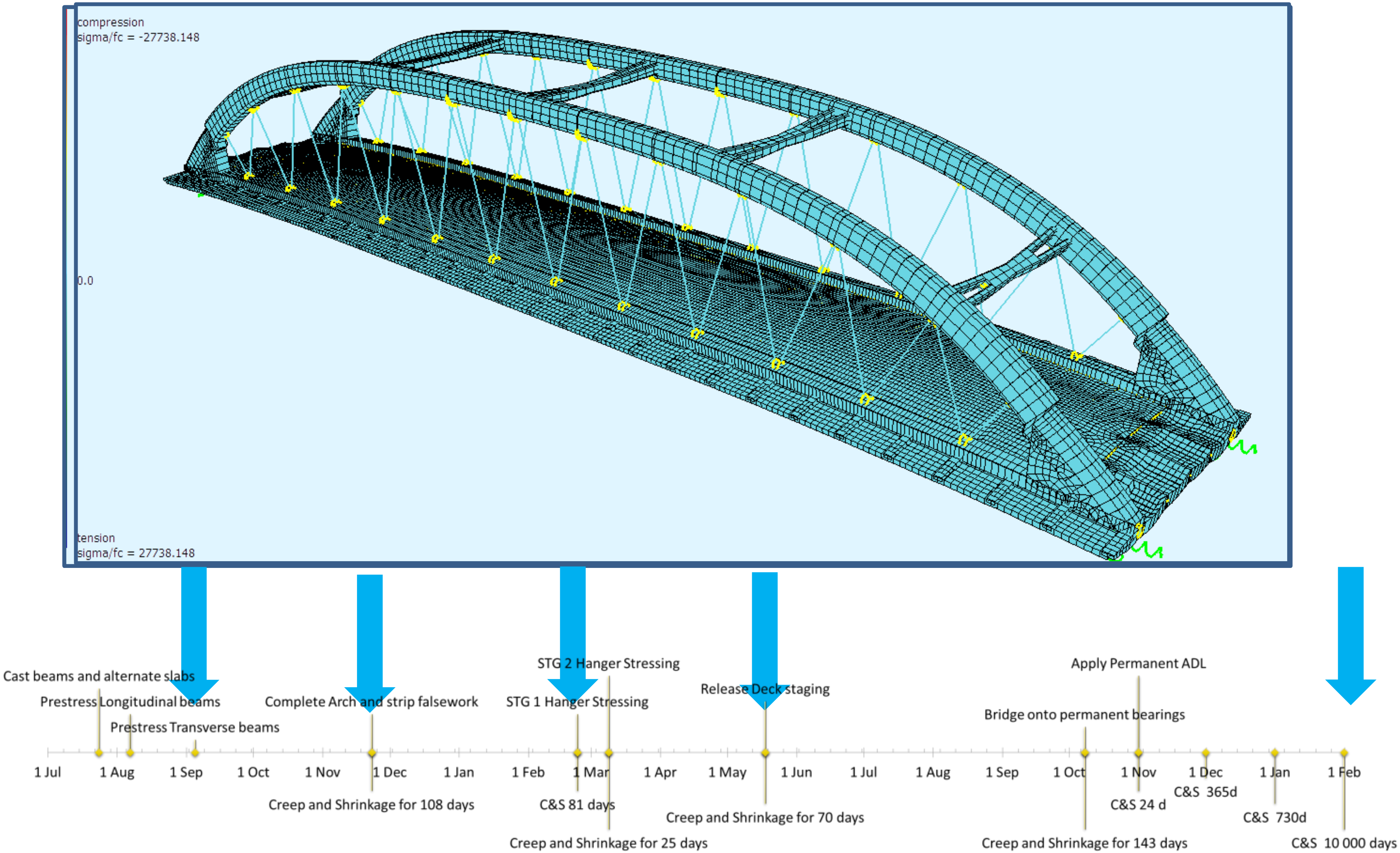
Deck False Work

- Soffit formwork
- Arch spring point

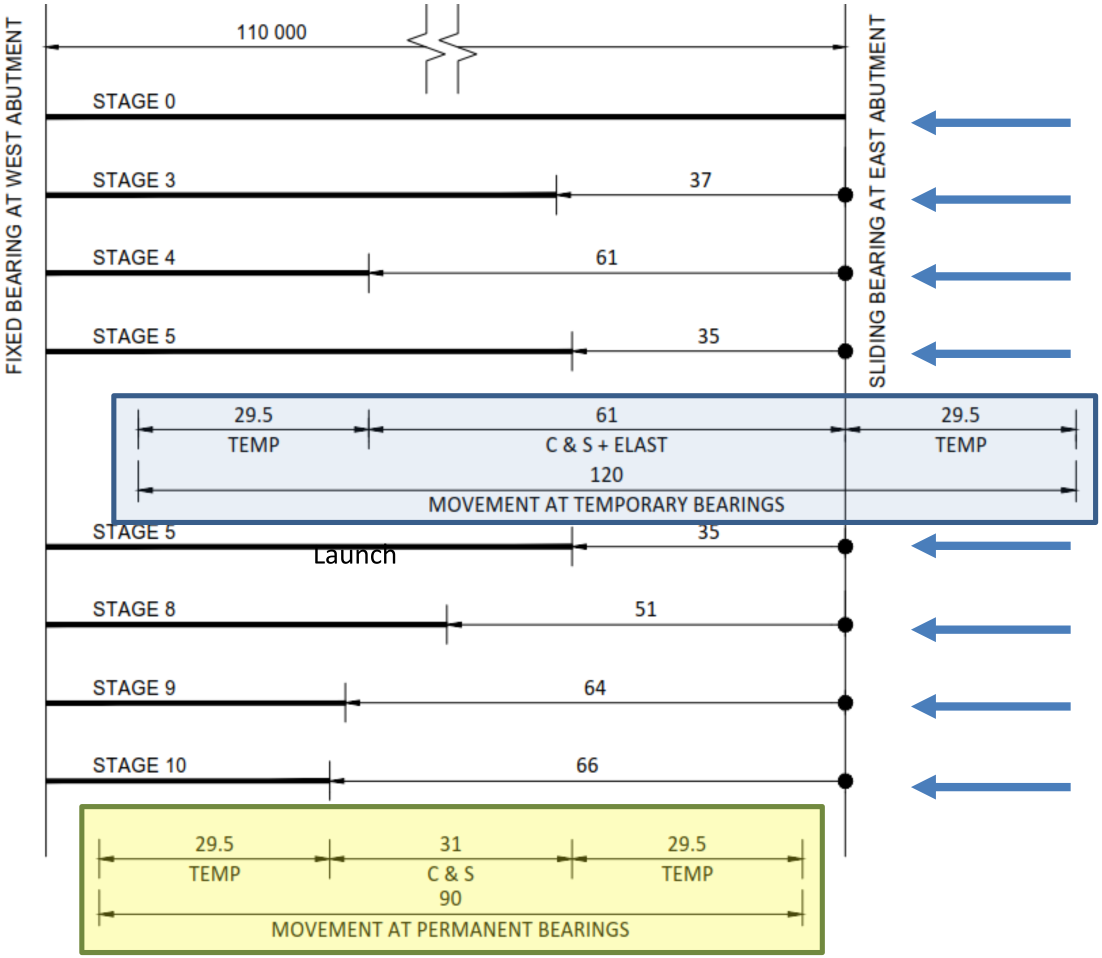
Structural Displacements

- Foundations
- Temporary works & falsework
- Permanent works during all construction stages & service life

Arch rib segmental construction


compression
sigma/fc = -27738.148
0.0
tension
sigma/fc = 27738.148
Cast beams and alternate slabs
Prestress Longitudinal beams
Prestress Transverse beams
Complete Arch and strip falsework
STG 2 Hanger Stressing
STG 1 Hanger Stressing
Release Deck staging
Apply Permanent ADL
Bridge onto permanent bearings
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
1 Jan
1 Feb
Creep and Shrinkage for 108 days
C&S 81 days
Creep and Shrinkage for 25 days
Creep and Shrinkage for 70 days
Creep and Shrinkage for 143 days
C&S 24 d
C&S 365d
C&S 730d
C&S 10 000 days

Horizontal Deck Movement



Completion of hit and miss construction

Stress longitudinal beams

Before installing hangers

After hanger installation

Temporary bearing movement range

Install perm bearings

ADL added

30 years C&S

Final C&S

Permanent bearing movement range

Stay Cable Lengths

- Unintentional variations (construction tolerances & modelling)
- Intentional variations (Time dependent material behaviour)
- Available fork socket tolerances

STAY CABLE NUMBER		Tolerance allowances (+ increase distance : - reduces distance)															TOTAL CONTROL SHORTENING OF THEORETICAL CHORD DISCTANCE
		Unintentioinal variation (extreme + or - indicated)								Intentional variations (actual + or - indicated)							
		Temporary works	Concrete works	Cast Anchors & fixing bolts	Cable Length manufacture	Fork socket	Structural model	Material properties	Total unintentional chord variance	Arch Deflection (After formwork removal)	Arch temp range	Cable temp range (20 deg var)	Arch Deflection (Cable Installation)	Deck deflection	Cable Elongation	Total Intentional chord variance	
NORTH	SOUTH	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
N1, N24	S1, S24	-2	-1	-10	-10	-5	-1	-1	-30	0	0	0	-4	-2	-7.37	-12	-42
N2, N23	S2, S23	-4	-2	-10	-10	-5	-2	-1	-35	0	0	0	-7	-2	-7.74	-16	-51
N3, N22	S3, S22	-4	-2	-10	-10	-5	-2	-1	-35	0	0	0	-7	-4	-15.18	-26	-61
N4, N21	S4, S21	-12	-6	-10	-10	-5	-5	-4	-52	0	0	0	-20	-4	-13.01	-37	-88
N5, N20	S5, S20	-12	-6	-10	-10	-5	-5	-4	-52	0	0	0	-20	-6	-20.61	-47	-98
N6, N19	S6, S19	-26	-13	-10	-10	-5	-11	-9	-83	0	0	0	-43	-6	-14.68	-64	-147
N7, N18	S7, S18	-26	-13	-10	-10	-5	-11	-9	-83	0	0	0	-43	-9	-27.13	-79	-162
N8, N17	S8, S17	-41	-21	-10	-10	-5	-17	-14	-117	0	0	0	-68	-9	-6.92	-84	-201
N9, N16	S9, S16	-41	-21	-10	-10	-5	-17	-14	-117	0	0	0	-68	-10	-31.92	-111	-228
N10, N15	S10, S15	-54	-27	-10	-10	-5	-23	-18	-147	0	0	0	-90	-10	-26.19	-126	-273
N11, N14	S11, S14	-54	-27	-10	-10	-5	-23	-18	-147	0	0	0	-90	-11	-37.30	-138	-285
N12, N13	S12, S13	-57	-29	-10	-10	-5	-24	-19	-154	0	0	0	-95	-11	-12.76	-119	-273

CONSTRUCTION CHALLENGES

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Original Construction Contract Termination

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Original Construction Contract termination & New Contracts

- Original Construction Contract was awarded to Basil Read Construction (BR) and commenced during 2015
- Contract was terminated during 2018 after BR was placed under business rescue
- H&I Construction was awarded an Interim Maintenance Contract to facilitate essential works and maintain traffic and safety measures.
- H&I Construction was also successful with the New Construction Contract which commenced during 2019
- Engineer and client appointed temporary works designer managed certain works during Interim Maintenance Contract & exercised control over free issue items eg. Post Tension installation, hanger anchors, falsework for arch etc.

Post tensioning

Post Tensioning

- Strand property verification
- Strand installation method & lubrication
- Duct condition verification ; Friction & Wobble calibration
- Lift off testing

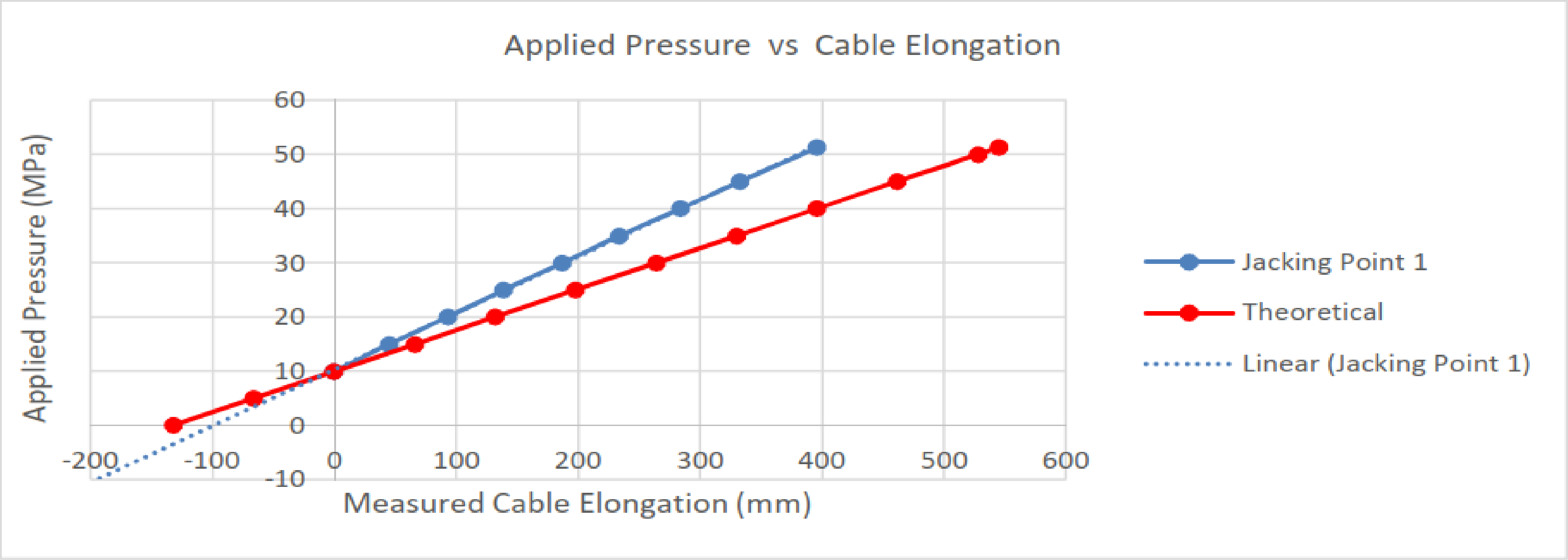
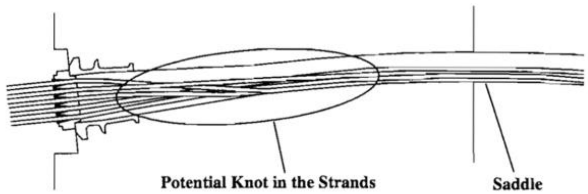


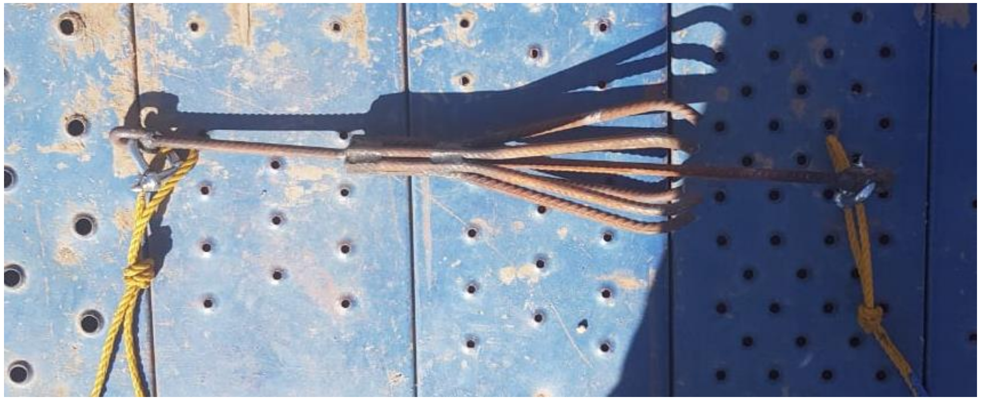
Figure 40 Elongation comparison

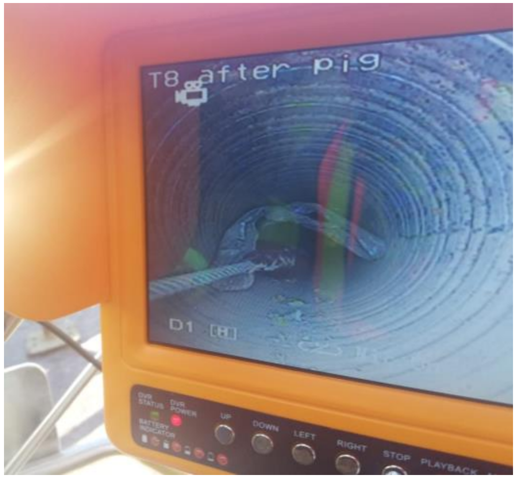
Post tensioning

Post tensioning



Post tensioning





Post tensioning

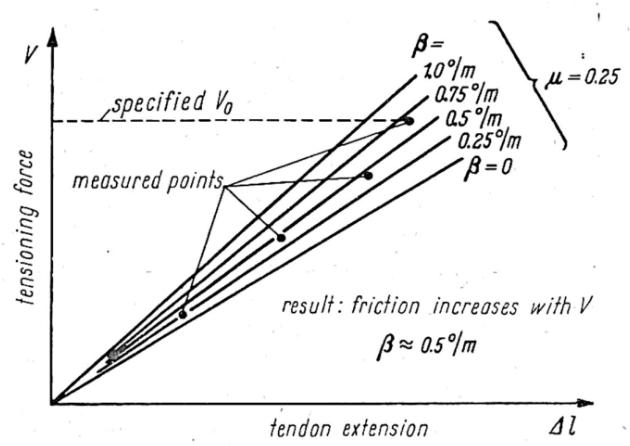
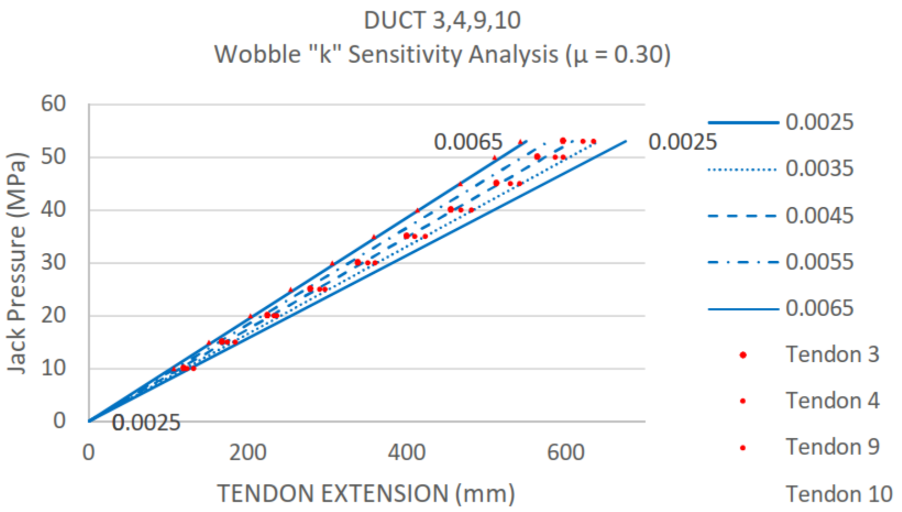
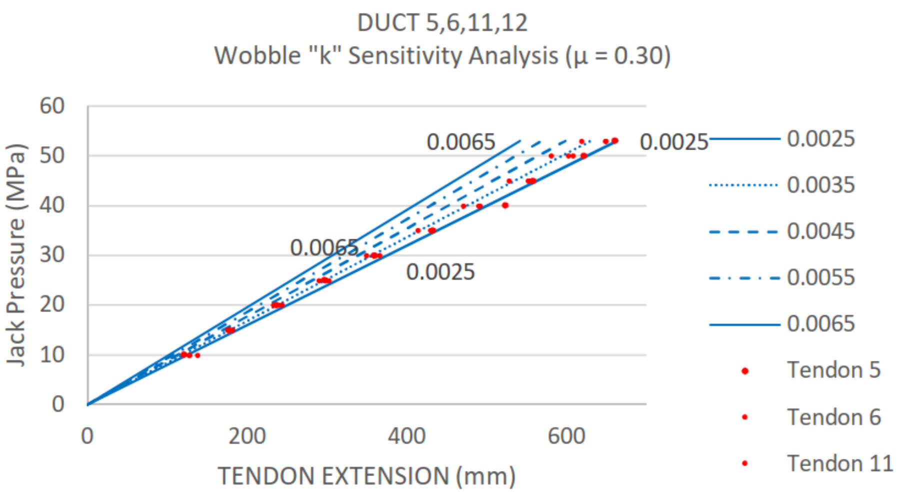


Figure 47 Wobble coefficient calibration (Leonhardt, 1964)





Post tensioning


Figure 49 Jack with magnetic precision Dial Gauge

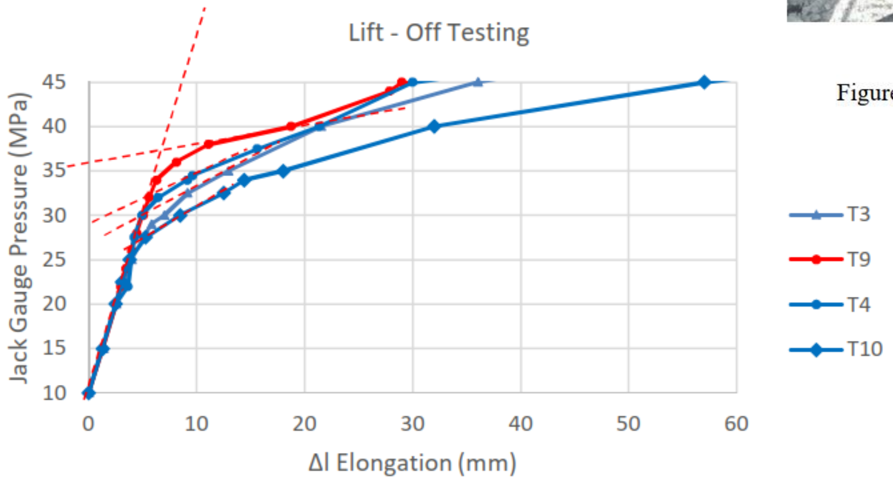


Figure 57 Typical lift off test results

Hanger anchors manufacturing

Hanger anchor manufacturing

- Rejection of original cast iron hangers
- Procurement & Manufacturing (International)
- QCP & Authorized Inspection Authority (OHS requirements)
- Compatibility & service life verifications (dimensional, fatigue, inspection & maintenance manuals)
- Important service life considerations
  - The structural form dictates that the anchors are subject to the following general loading regime:
    - A free tensile load in which (in a failure situation) a significant proportion of the load would still be applied up to rupture
    - Limited redundancy with potential susceptibility to “unzipping” failure
  - The form of the anchor connection results in a partial creation of a hidden critical element (the embedded section), that means subsequent complete inspection will be difficult.

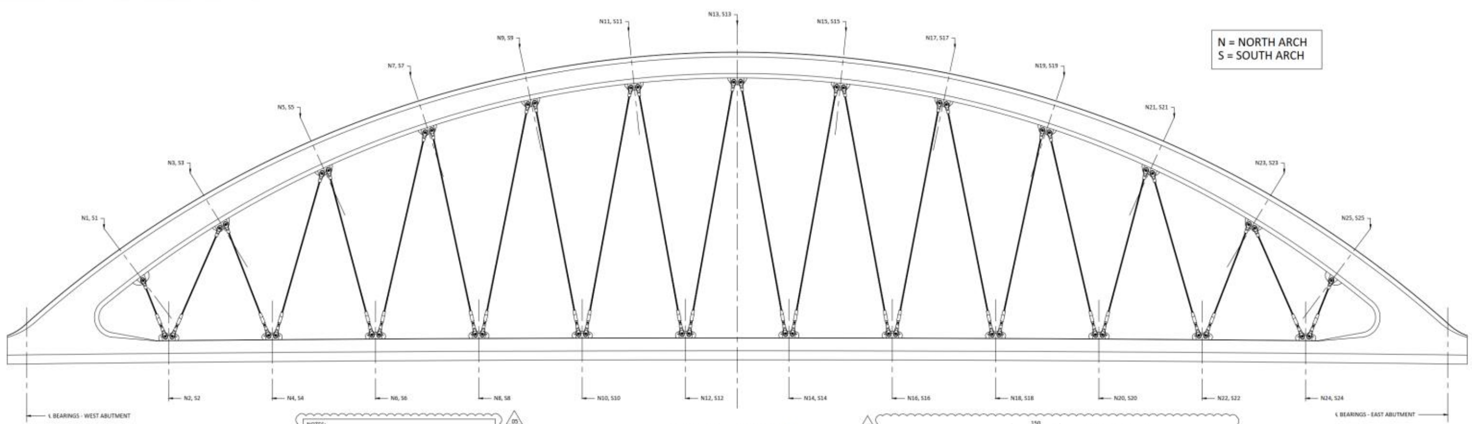
Hanger anchor manufacturing

- Rejection of original cast iron hangers due to inadequate durability and fatigue resistance parameters
- Procurement & Manufacturing (International) resulted in new compound steel plate solutions in view of programming constraints
- Compatibility & service life verifications (dimensional, fatigue, inspection & maintenance manuals) with important service life considerations
- The structural form dictates that the anchors are subject to the following general loading regime:
    - A free tensile load in which (in a failure situation) a significant proportion of the load would still be applied up to rupture
    - Limited redundancy with potential susceptibility to “unzipping” failure
  - The form of the anchor connection results in a partial creation of a hidden critical element (the embedded section), that means subsequent complete inspection will be difficult

Hanger anchor manufacturing

AECOM SA approaches				AECOM UK Ltd
Scenario description	**Impact on programme**	**Actions**	**Risks**	**REVIEW COMMENT**
Scenario A: Acceptance in current condition based on a Fit for Service (FFS) analysis	Only scenario that would allow pre arch casting installation	AECOM UK specialists to advise on probability of successful outcome based on available information	Negative FFS result, uncertain long-term effect on structural system	Unlikely to be sufficient considering the variability of defects and number of components. Even if metallurgical FFS recommendation is positive it will be difficult to align with structural design responsibility for a new 120 year lifespan public CC3 structure.
Scenario B: Re-heat treatment of all anchor plate	Process would require post arch casting installation	Assess effects of re-heat treatment and property improvement probability	This may provide the least duration risk, metallurgical view not too positive with current casting material composition	Metallurgical specialist advice appears to doubt this route but has to be discussed in detail. Substantial upgrade of Charpy and %elongation results required to meet the spec are difficult to achieve, particularly when considering the large number of potentially affected cast components. Post arch casting installation would require careful consideration to avoid incorporation of a defect.
Scenario C: Remanufacture of all components	Process would require post arch casting installation	Steel castings or steel plate manufacturing options to be considered with costs, sourcing internationally & delivery	Indications are that a minimum 6 month procurement process required, any delays could significantly impact on construction	This is the structurally safe option based on the currently available and presented information. Efforts to minimise the cost and programme implications could be made but are nevertheless likely to be significant. Post arch casting installation would require careful consideration to avoid incorporation of a defect.
Scenario D: Strengthening of all components	Process would require post arch casting installation	Ultra-high strength steel plate strengthening options to be considered with feasibility, cost etc.	Feasibility uncertain but may be easier than remanufacturing with reduced cost implication	Based on the nature of the defects, the number and shape of the cast components this option is not considered feasible. Welding high strength plates to this type of high yield casting would be problematic and could potentially make matters worse.

A88/285



ELEVATION - SETTING OUT
ANCHOR PLATES
SCALE 1:125

ANCHOR PLATES

PLATE NO	PLATE TYPE	SV
N1, S1	TYPE 3	17710.800
N2, S2	TYPE 1	17713.000
N3,S3	TYPE 2	17717.000
N4,S4	TYPE 1	17721.000
N5,S5	TYPE 2	17725.000
N6,S6	TYPE 1	17729.000
N7,S7	TYPE 2	17733.000
N8,S8	TYPE 1	17737.000
N9,S9	TYPE 2	17741.000
N10,S10	TYPE 1	17745.000
N11,S11	TYPE 2	17749.000
N12,S12	TYPE 1	17753.000
N13,S13	TYPE 2	17757.000
N14,S14	TYPE 1	17761.000
N15,S15	TYPE 2	17765.000
N16,S16	TYPE 1	17769.000
N17,S17	TYPE 2	17773.000
N18,S18	TYPE 1	17777.000
N19,S19	TYPE 2	17781.000
N20,S20	TYPE 1	17785.000
N21,S21	TYPE 2	17789.000
N22,S22	TYPE 1	17793.000
N23,S23	TYPE 2	17797.000
N24,S24	TYPE 1	17801.000
N25,S25	TYPE 3	17803.200

ADDITIONAL NOTES FOR STRESSED BARS:

1. AFTER STRESSING OF THE STRESSED BARS HAVE BEEN COMPLETED AND ACCEPTED BY THE ENGINEER THE END OF THE STRESSED BAR SHALL BE CUT OFF WITH A MINIMUM LENGTH OF 30mm PROTRUDING FROM THE HEXAGONAL NUT.
2. GROUTING OF THE STRESSED BARS SHALL THE BE CARRIED OUT.
3. THE EXPOSED SURFACES INSIDE THE ANCHOR PLATE RECESSES INCLUDING THE ANCHOR PLATES, HEXAGONAL NUTS AND ENDS OF PROTRUDING BARS SHALL THEN BE CLEANED THOROUGHLY IN ORDER TO REMOVE ALL LOOSE MATERIAL AND ALL TRACES OF CEMENT, GREASE, OIL RUST AND MILL SCALE.
4. APPLY TWO COATS OF SIKATOP-ARMATEC 110 EPOCEM TO THE EXPOSED STEEL SURFACES ESPECIALLY OVER THE ENDS OF THE PROTRUDING BARS
5. THE BEND-OUT BARS SHALL THEN BE BENT INTO POSITION AND THE ANCHOR PLATE RECESSES BE FILLED WITH THE MATERIAL AS SPECIFIED.
6. THE EXPOSED SURFACE AREA OF THE ANCHOR RECESSES AND AT LEAST 150mm BEYOND THE EDGES OF RECESSES SHALL BE TREATED WITH A SURFACE FINISH OF SIKA MONOTOP 620.
7. ALL PROPRIETY PRODUCTS SHALL BE APPLIED, AND THE SUBSTRATE PREPARED, STRICTLY IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATION AND INSTRUCTIONS FOR USE.

NOTES:

1. STEEL PLATES

1.1 ALL STEEL PLATES SHALL BE GRADE S355J2+N ONLY TO BS EN 10025-2:2019. 50mm THICK BASE PLATE AND LOWER 375mm PORTION OF 50mm THICK ANCHOR PLATE TO BE Z35 THROUGH THICKNESS QUALITY MATERIAL TO BS EN10164.

1.2 ALL STEEL WORK SHALL BE IN ACCORDANCE WITH THE NOTES FOR FABRICATED STEEL ANCHOR PLATES REFER TO DRAWINGS A88/286 60326278-01-11-1132 AND A88/287 60326278-01-11-1133.

1.3 ALL ELEMENTS ON THIS DRAWING SHALL BE QUANTIFIED SERVICE CATEGORY F71 UNLESS NOTED OTHERWISE.

1.4 ALL HOLES TO BE MACHINE FORMED TO THE DIAMETERS AS SHOWN.

1.5 REFER TO DRAWING A88/287 60326278-01-11-1133 FOR WELDING SEQUENCE CLARIFICATION DIAGRAM.

1.6 ALL ANCHOR PLATES TO BE HOT-DIPPED GALVANIZED WITH A MINIMUM THICKNESS OF 85μm.

2. PROCESS CONTROL AND TESTING

PROCESS CONTROL AND TESTING OF STEEL ELEMENTS SHALL BE IN ACCORDANCE WITH THE NOTES FOR FABRICATED STEEL ANCHOR PLATES REFER TO DRAWINGS 60326278-01-11-1132 AND 60326278-01-11-1133.

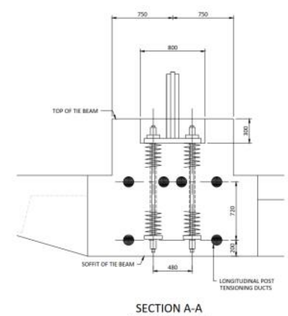
3. STRESS BARS

STRESS BARS AT ALL ANCHOR PLATES DIAMETER 40mm YIELD STRESS 950 MPa ULTIMATE TENSILE STRENGTH 1050 MPa. BARS EACH TO BE STRESSED TO 50% UTS (660kN)

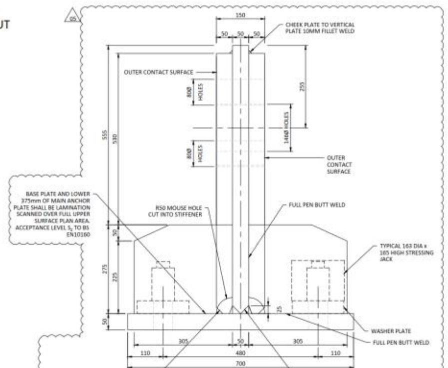
REFERENCE DRAWINGS:

ANCHOR PLATE TYPE 2: A88/286 60326278-01-11-1132

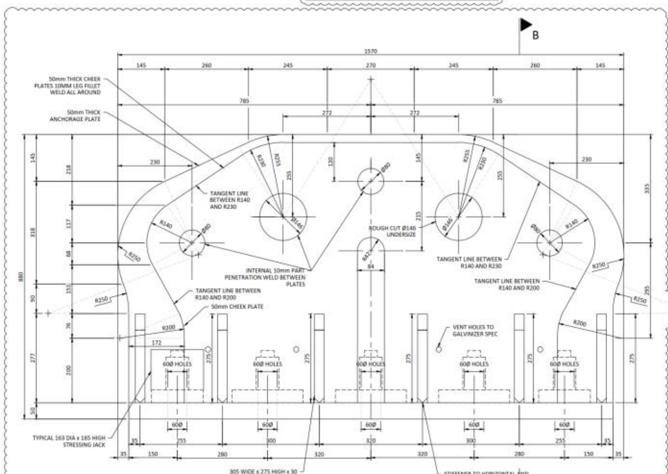
ANCHOR PLATE TYPE 3: A88/287 60326278-01-11-1133



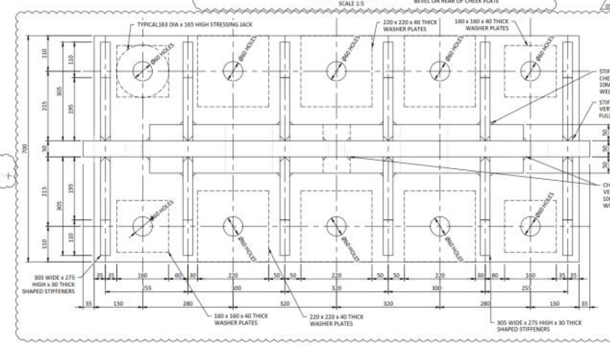
SECTION A-A
ANCHOR PLATE TYPE 1
SCALE 1:20



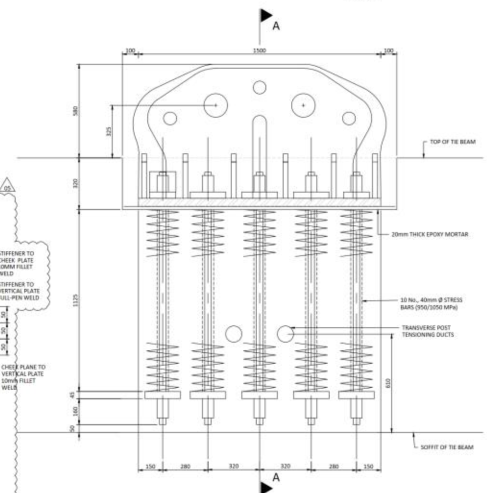
SIDE ELEVATION
ANCHOR PLATE TYPE 1
SCALE 1:5



DETAIL
ANCHOR PLATE TYPE 1
SCALE 1:5



PLAN
ANCHOR PLATE TYPE 1
SCALE 1:5



ELEVATION
ANCHOR PLATE TYPE 1
SCALE 1:10

FOR MANUFACTURING

No.	DATE	ADDITIONS AND AMENDMENTS	APPROVED CONS. ENG.	APPROVED PRE
01	26/06/2019	AMENDMENTS TO ANCHOR PLATES DETAILS	A.A. NEWMARK	N/A
02	03/09/2019	CHANGE OF STEEL GRADE AND DIMENSIONS	A.A. NEWMARK	N/A
03	09/09/2019	AMENDMENTS TO NOTES ON ANCHOR PLATES	A.A. NEWMARK	N/A
04	17/09/2019	AMENDMENTS TO ANCHOR PLATES DETAILS	A.A. NEWMARK	N/A
05	27/09/2019	AMENDMENTS TO ANCHOR PLATES DETAILS	A.A. NEWMARK	N/A

DESIGNED BY: S. BARON
CHECKED BY: A.A. NEWMARK
DRAWN BY: K.R. MEYER
CHECKED BY: P. RONNIE

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A.A. NEWMARK
CONSULTING ENGINEERS
DATE 27/09/2019

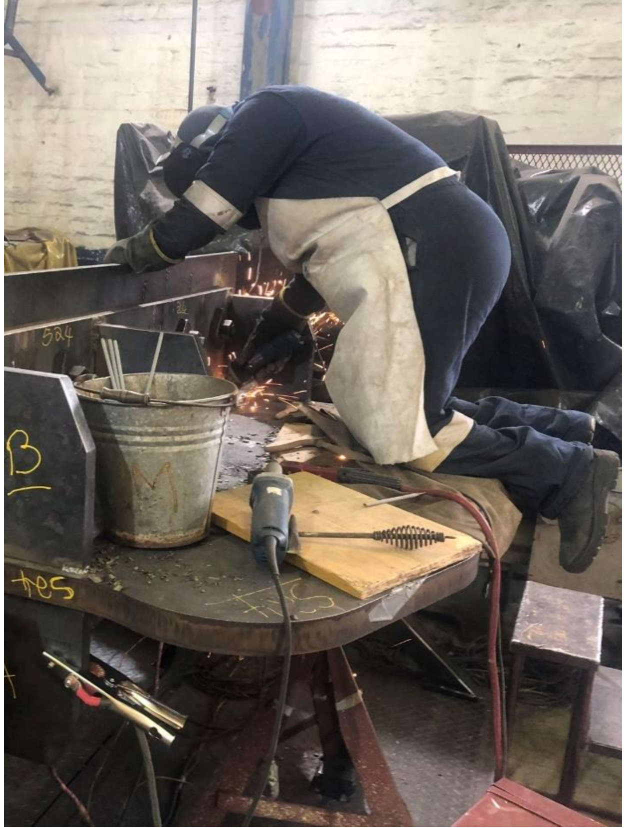
WESTERN CAPE GOVERNMENT
DEPARTMENT OF TRANSPORT AND PUBLIC WORKS

APPROVED
THIS APPROVAL IS FOR PROCEDURAL AND ADMINISTRATIVE REVIEW PURPOSES ONLY AND DOES NOT ATTRACT LEGAL LIABILITY OF ANY KIND FROM WHATSOEVER CAUSE OR HOWEVER ARISING
ORIGINAL VERSION SIGNED BY J.NEETHLING ON 04/09/2019
PROVINCIAL ROADS ENGINEER
DATE

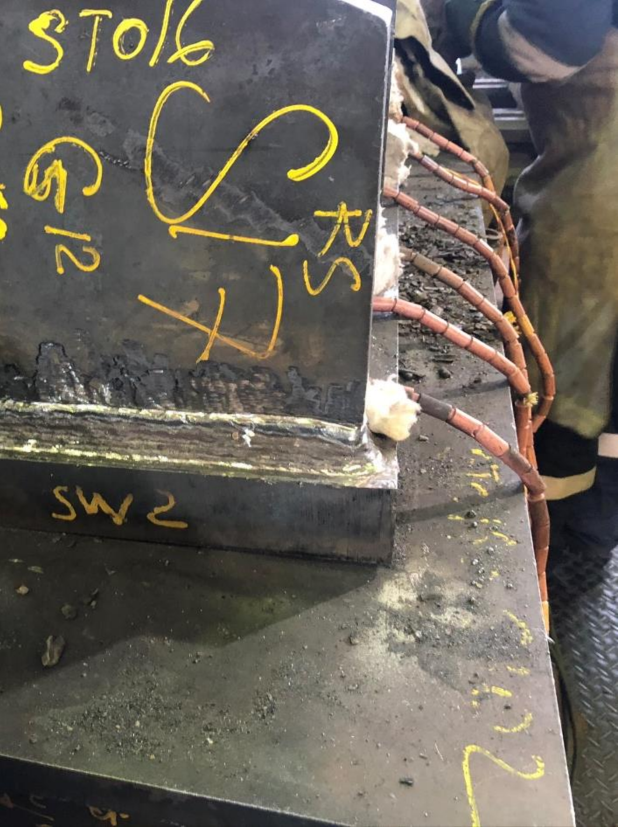
PROPOSED BRIDGE NO. 2666 ON TR31/2 IN ASHTON OVER THE COGMANSKLOOF RIVER AT KM 17.76

ALTERNATIVE ANCHOR PLATE DETAIL 1

P.R.E.'s FILE No.: TPW 16/6/4/1/2 – 818.01
SCALE: AS SHOWN
CONTRACT No.: C818.01
WCG STRUCTURES PLAN No.: 2666/31
CONSULTANT'S PLAN No.: 60326278-01-11-1131-C-05
WCG INDEX No.: A88/285



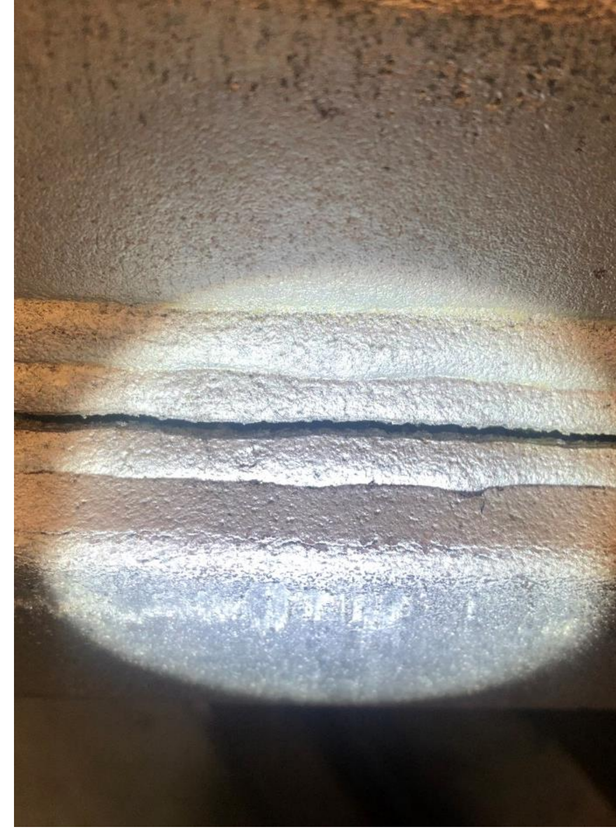
Welding operations



Welding operations

Machining operations

Heat treatment and quality control



Galvanizing trials

Thermal Metal Spray and paint coating

Coating System :

- TMS (Zinc , 125 micron)
- Carboguard 635 (150 micron)
- Carbothane 137 HS (90 micron)

Hanger Anchor Installation

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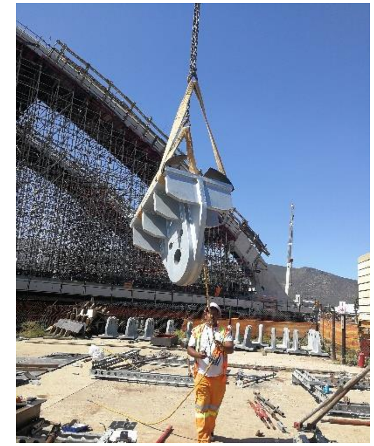
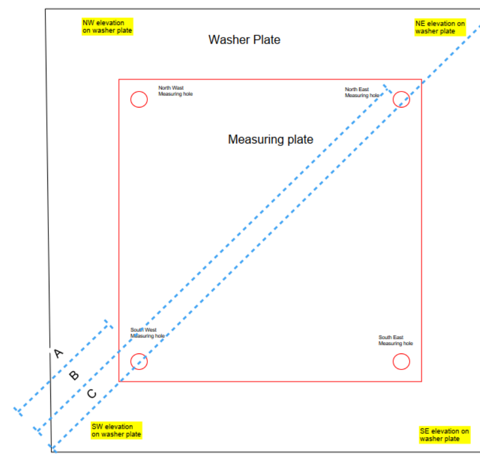




NW elevation on washer plate
Washer Plate
NE elevation on washer plate
North Wast Measuring hole
North East Measuring hole
Measuring plate
South West Measuring hole
South East Measuring hole
A
B
C
SW elevation on washer plate
SE elevation on washer plate

Installation testing

	Average			Average			Average			Average			Average	
Avg N	258.32418		Avg N	255.83		Avg N	255.65		Avg N	258.51		Avg N	260.31	
Avg S	260.04082		Avg S	259.03		Avg S	258.92		Avg S	260.81		Avg S	259.79	
AvgW	259.03176		AvgW	256.97		AvgW	256.98		AvgW	258.71		AvgW	259.24	
Avg E	259.33324		Avg E	257.88		Avg E	257.59		Avg E	260.6		Avg E	260.86	
diff		Worst Case	diff		Worst Case	diff		Worst Case	diff		Worst Case	diff		Worst Case
W to E	0.3014872	1.7166	W to E	0.902	3.1995	W to E	0.6127	3.2676	W to E	1.8891	2.2975	W to E	1.612	1.612
N to S	1.7166313		N to S	3.1995		N to S	3.2676		N to S	2.2975		N to S	0.5168	

	Bolt 1			Bolt2			Bolt3			Bolt4			Bolt 5	
	Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]
NW	258.35	258.16	NW	256.29	255.45	NW	256.23	255.44	NW	258.23	257.37	NW	259.38	259.28
SE	259.99	260.18	SE	258.7	259.55	SE	258.51	259.32	SE	260.69	261.56	SE	260.27	260.37
NE	258.62	258.49	NE	256.67	256.2	NE	256.41	255.87	NE	259.73	259.65	NE	261.14	261.34
SW	259.77	259.9	SW	258.02	258.5	SW	257.97	258.52	SW	259.97	260.05	SW	259.41	259.21

Measured: 27/05/2020

258.16	258.49	255.45	256.2	255.44	255.87	257.37	259.65	259.28	261.34
1		2		3		4		5	
259.9	260.18	258.5	259.55	258.52	259.32	260.05	261.56	259.21	260.37

Anchor N2

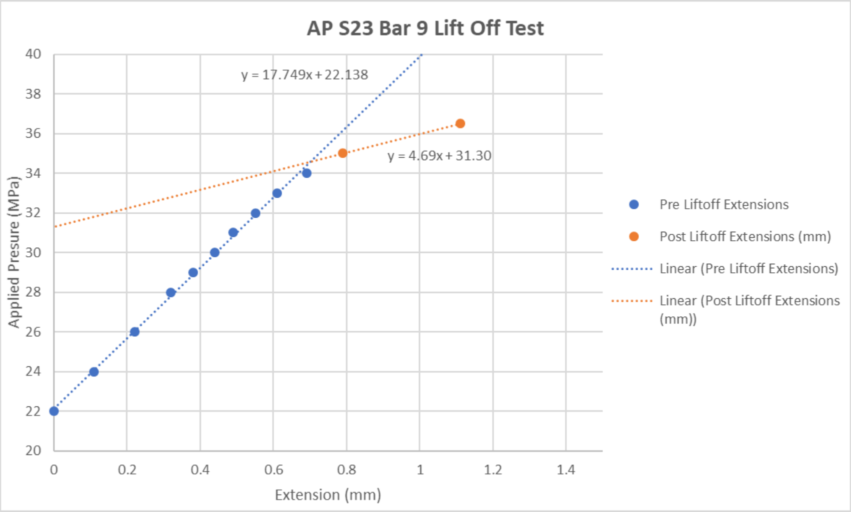
262.64	260.93	261.4	262.15	258.19	258.68	259.99	259.22	258.79	259.34
10		9		8		7		6	
259.35	258.34	258.53	259	255.35	256.28	256.1	254.71	256.75	257.54

	Bolt 10			Bolt 9			Bolt8			Bolt7			Bolt 6	
	Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]		Measuring plate value	Washer plate extrapolated [illegible]
NW	262.24	262.64	NW	260.91	261.4	NW	257.8	258.19	NW	258.91	259.99	NW	258.67	258.79
SE	258.74	258.34	SE	259.5	259	SE	256.68	256.28	SE	255.81	254.71	SE	257.66	257.54
NE	260.78	260.93	NE	261.41	262.15	NE	258	258.68	NE	258.58	259.22	NE	259.1	259.34
SW	259.5	259.35	SW	259.28	258.53	SW	256.04	255.35	SW	256.75	256.1	SW	256.99	256.75

	Average			Average			Average			Average			Average	
Avg N	261.78552		Avg N	261.78		Avg N	258.44		Avg N	259.6		Avg N	259.06	
Avg S	258.84448		Avg S	258.76		Avg S	255.81		Avg S	255.41		Avg S	257.15	
AvgW	260.99796		AvgW	259.96		AvgW	256.77		AvgW	258.05		AvgW	257.77	
Avg E	259.63204		Avg E	260.58		Avg E	257.48		Avg E	256.96		Avg E	258.44	
diff		Worst Case	diff		Worst Case	diff		Worst Case	diff		Worst Case	diff		Worst Case
W to E	1.3659217	2.941	W to E	0.6127	3.0123	W to E	0.7148	2.6209	W to E	1.0807	4.1951	W to E	0.6768	1.9197
N to S	2.9410386		N to S	3.0123		N to S	2.6209		N to S	4.1951		N to S	1.9197	

Washer plate machining

Arch Anchor plates



- 2 or more tensioning cycles result less anchorage losses according to Macalloy bar literature
- 3 stressing cycles on Arch anchor plates.

Tie Beam Anchor plates

- Bars shorter than the Arch ones.
- 4 stressing cycles

Anchor plate tensioning summary

- 484 bars tensioned
- Over 1200 lift-off tests
- Over 1900 washer plate alignment measurements
- 2400 litres of grout

Hanger Installation

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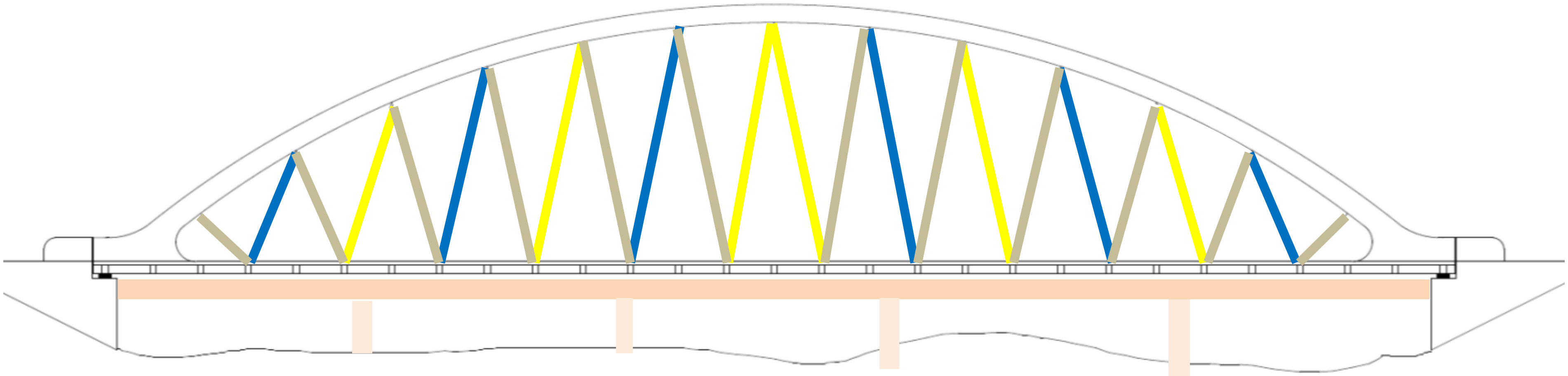
Utilisation of the C-hook

Utilisation of the C-hook

Hanger Tensioning

Hanger tensioning sequence

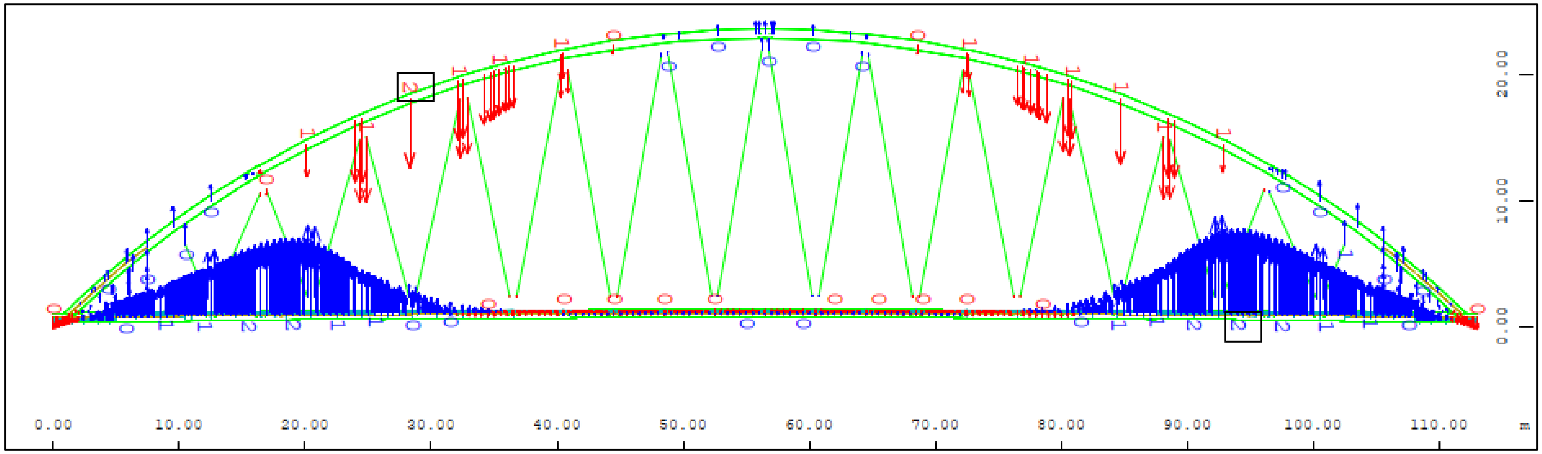


Stage 1 = 50% of load -> Stage 2 = 100% load

The intent of this process was to start by removing the slack from the cables and to get some stiffness into the structural system before the cables are sequentially stressed to their design force

Simultaneous tensioning of 2 cables per Arch

Live structural monitoring during tensioning



Tensioning checks and calculations

Instrumentation and Monitoring

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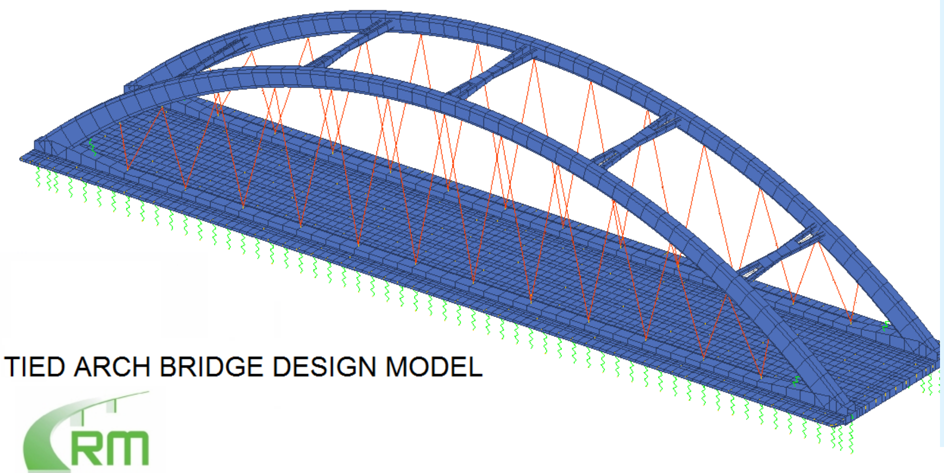
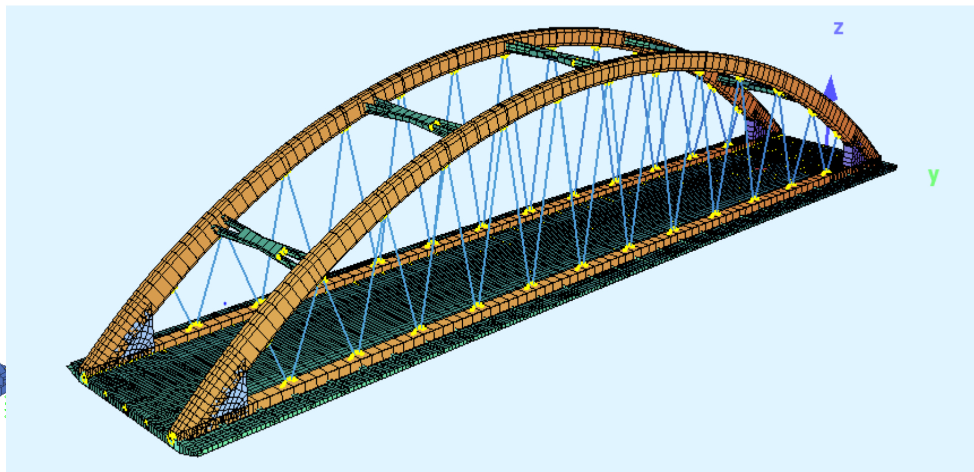
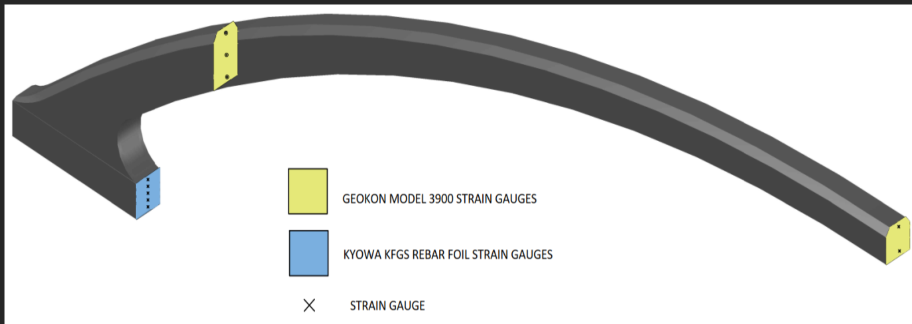
FEM Model Review and Calibration

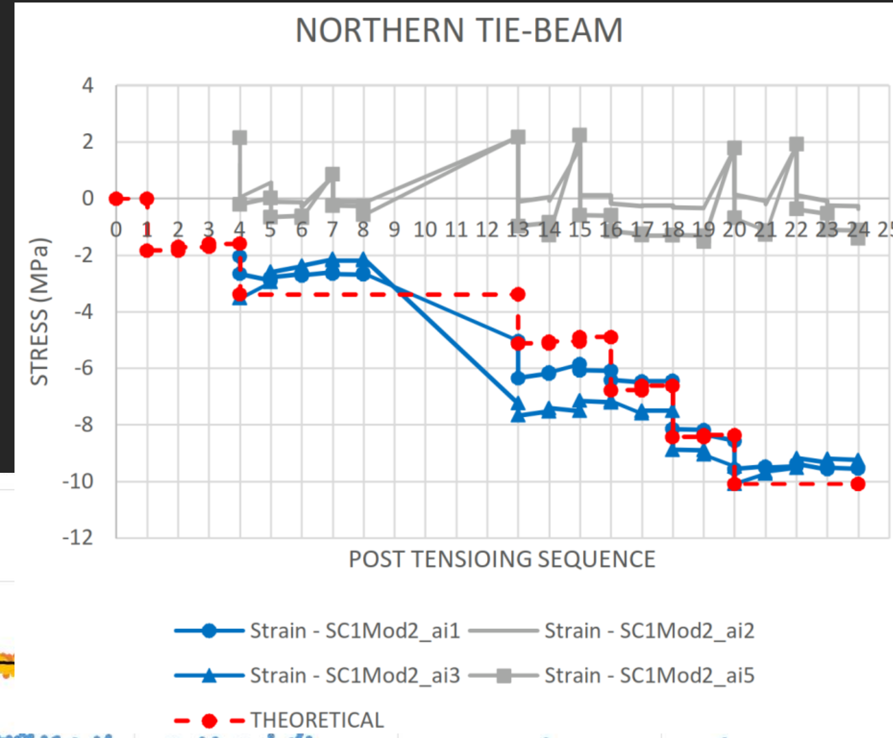
Bentley RM Bridge Advanced V8	Sofistik 2014
AECOM SA design	AECOM UK
30 Construction Stages	89 Construction Stages
Rigid support for deck falsework	Calculated stiffness for deck falsework
Spring point modeled with rigid links	Springing point modeled with shell elements
C&S models – BS 5400	C&S models – TMH 7

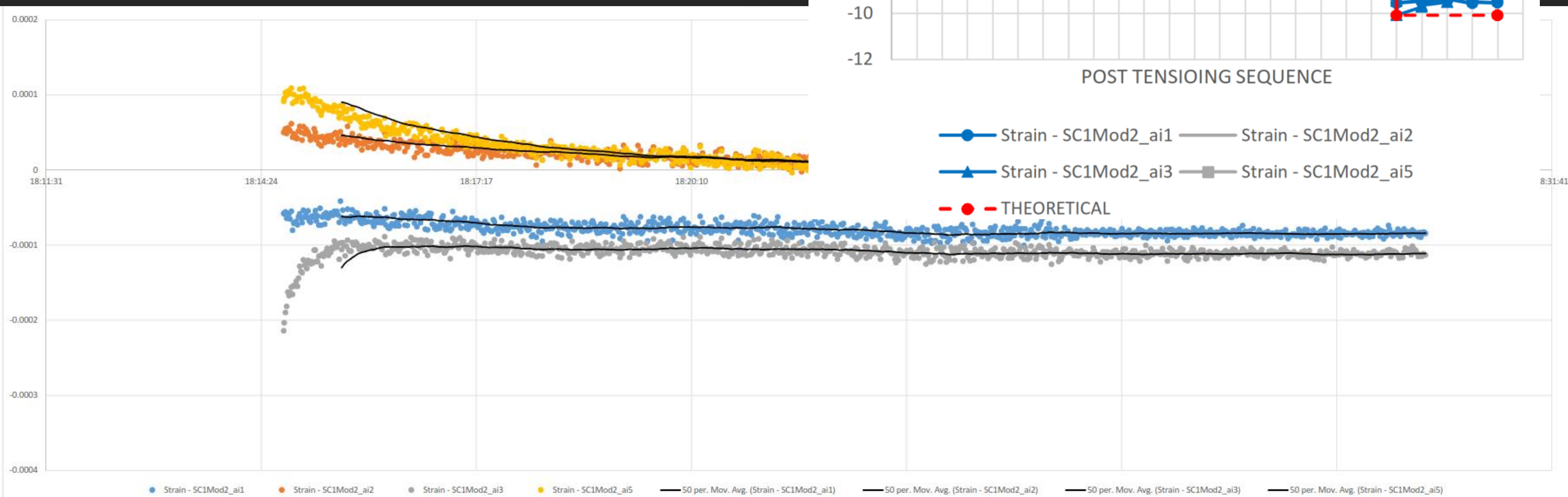




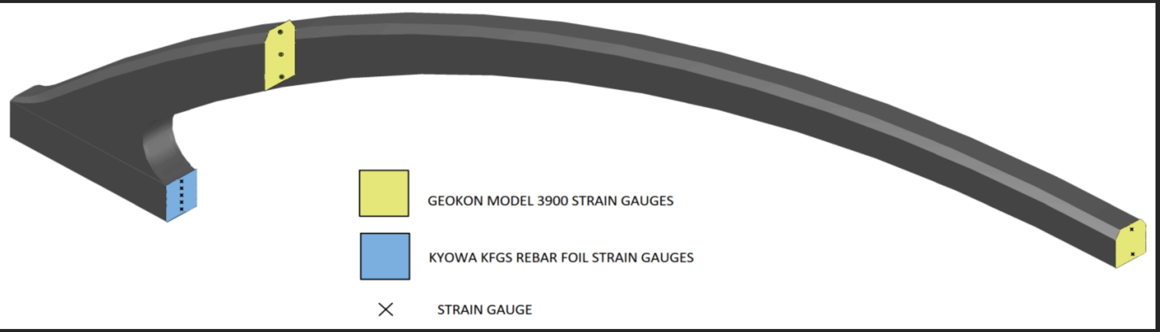
Strain Monitoring



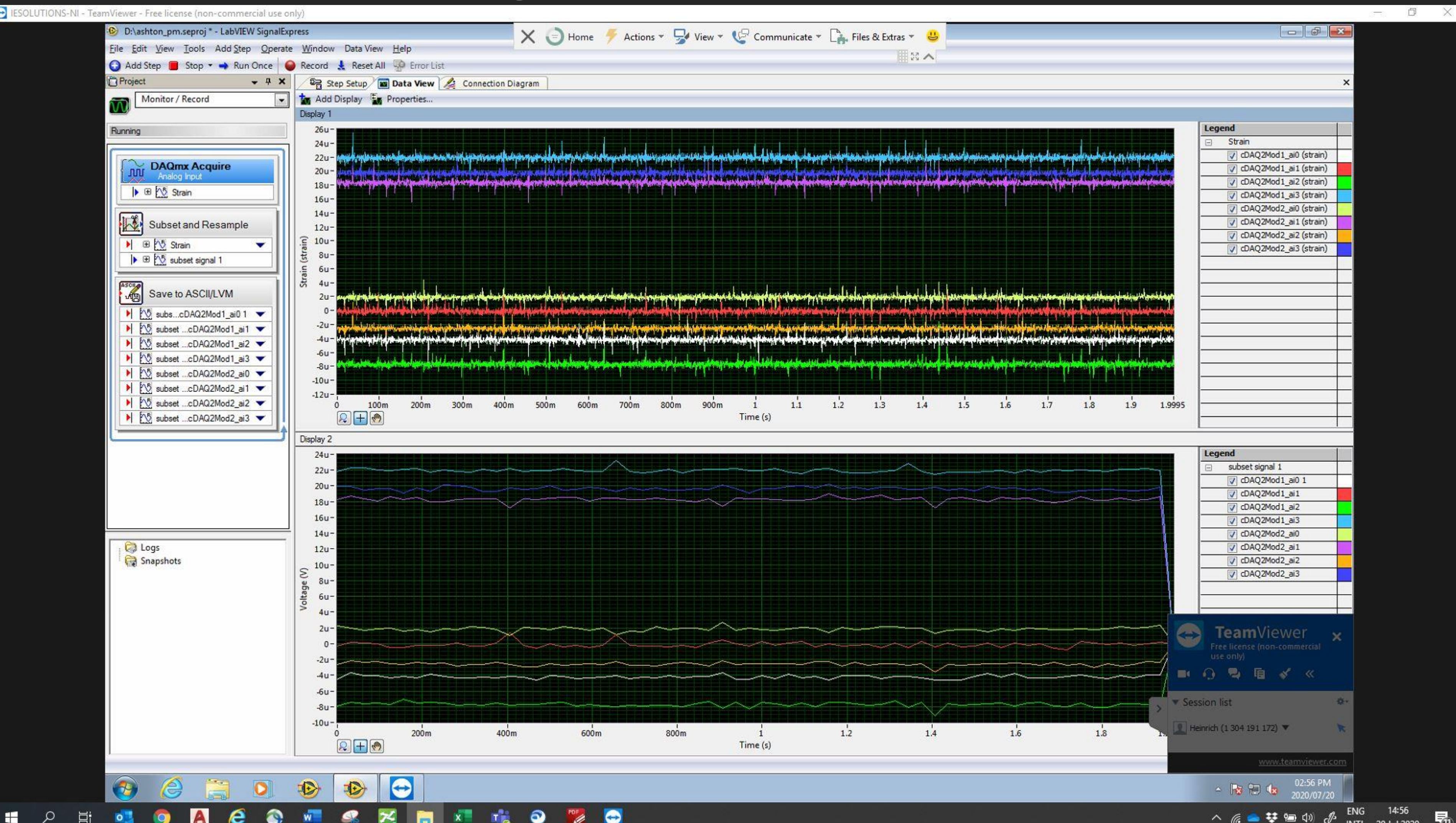




Strain Monitoring



Strain Monitoring



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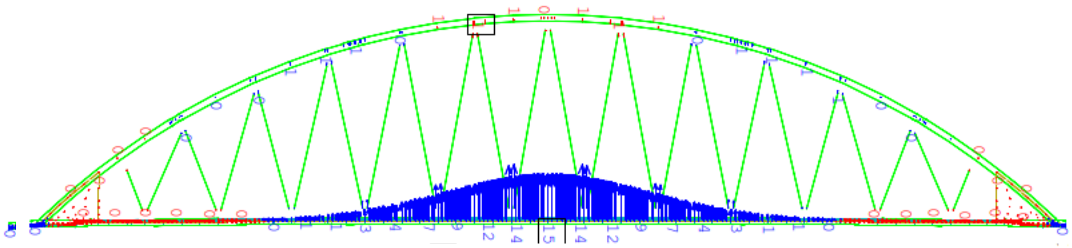
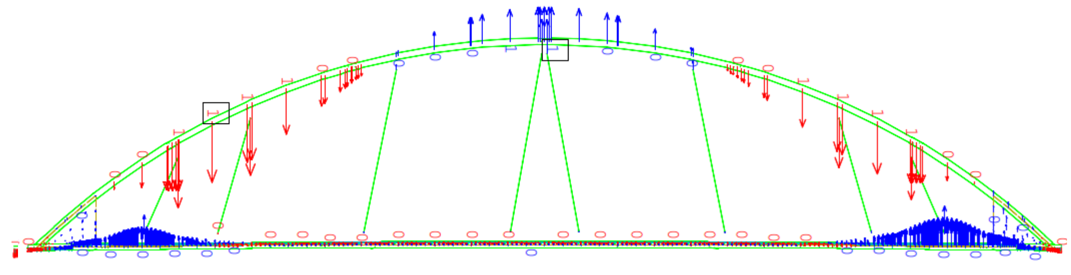


Displacement monitoring

Cable Tension Measurement



Cables		Stage 1 Cable Installation											
		4101	4102	4103	4104	4105	4106	4107	4108	4109	4110	4111	4112
		STG4H	STG4J	DTG4L	STG4G	STG4I	STG4K	STG4A	STG4B	STG4C	STG4D	STG4E	STG4F
N	4	650	682	886	850	758	845	820	718	587	472	442	445
N	8		930	684	687	600	399	420	472	493	393	190	44
N	12			793	810	827	434	456	531	626	669	576	249
N	2				466	429	472	414	323	257	211	194	184
N	6					825	809	819	821	735	561	450	421
N	10						1019	1042	1114	1193	1198	1030	749
N	1							867	693	666	696	756	806
N	3								913	766	762	856	963
N	5									962	842	868	976
N	7										1115	999	1024
N	9											1213	1087
N	11												1208

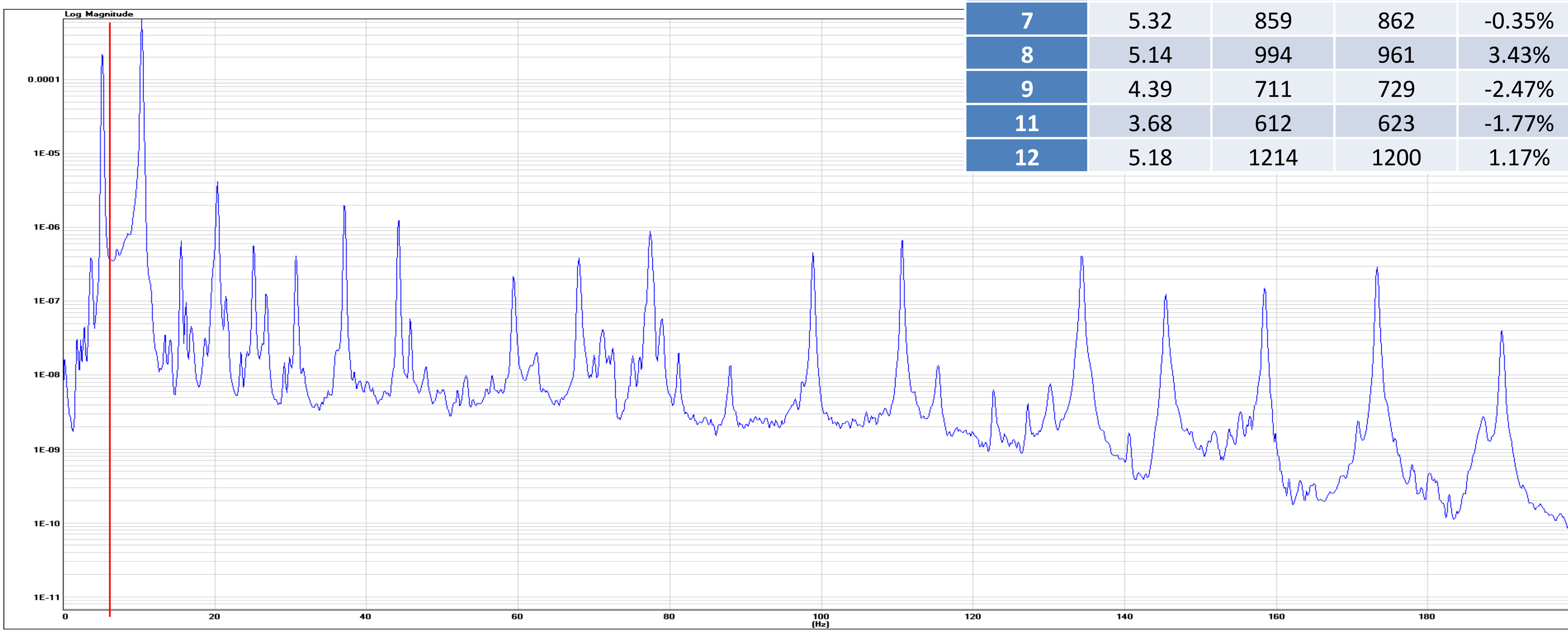
Cables		Stage 2 Cable Installation											
		4121	4122	4123	4124	4125	4126	4127	4128	4129	4130	4131	4132
		STG4HH	STG4JJ	DTG4LL	STG4GG	STG4II	STG4KK	STG4AA	STG4BB	STG4CC	STG4DD	STG4EE	STG4FF
N	4	1089	1055	1043	986	828	813	797	730	631	565	571	599
N	8	0	1092	961	956	828	626	627	623	582	436	267	183
N	12	178	100	1200	1198	1182	870	872	885	919	964	839	388
N	2	81	63	51	688	643	637	612	569	534	522	536	549
N	6	282	186	155	137	988	919	916	887	783	631	569	584
N	10	664	552	189	186	151	1317	1318	1324	1330	1293	1115	831
N	1	744	788	818	739	716	741	1131	1035	994	1002	1014	1021
N	3	817	888	966	906	813	869	827	1217	1078	1038	1034	1051
N	5	806	831	938	909	729	780	769	696	1215	1054	975	985
N	7	877	785	862	852	702	676	677	665	571	1335	1105	1040
N	9	975	811	729	723	653	485	488	498	493	391	1375	1118
N	11	1119	1003	623	620	590	313	316	333	367	396	190	1234

Cable Tension Measurement

$T = 4f^2Lm$

Cable tension Measurement

Cable number	Measured first natural frequency (Hz)	Measured force (kN)	Targed force (kN)	% difference
5	6.96	944	938	0.64%
7	5.32	859	862	-0.35%
8	5.14	994	961	3.43%
9	4.39	711	729	-2.47%
11	3.68	612	623	-1.77%
12	5.18	1214	1200	1.17%



$T = 4f^2Lm$

Adverse founding conditions

Adverse founding conditions at west abutment

- Significant amount of ground water
- comprehensive re-assessment
- 5 design scenarios were tested in the market to assess the cost and programme aspects.
- A large diameter (>1000mm) piling solution with approximate 10m length was adopted

TRANSVERSE LAUNCHING

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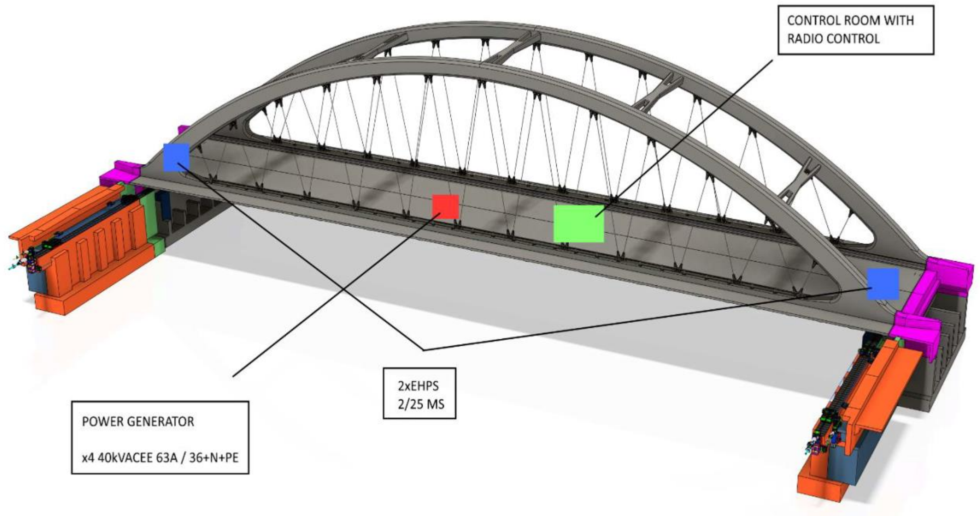
Transverse Launching

The proposed launching system consists of the following main components:

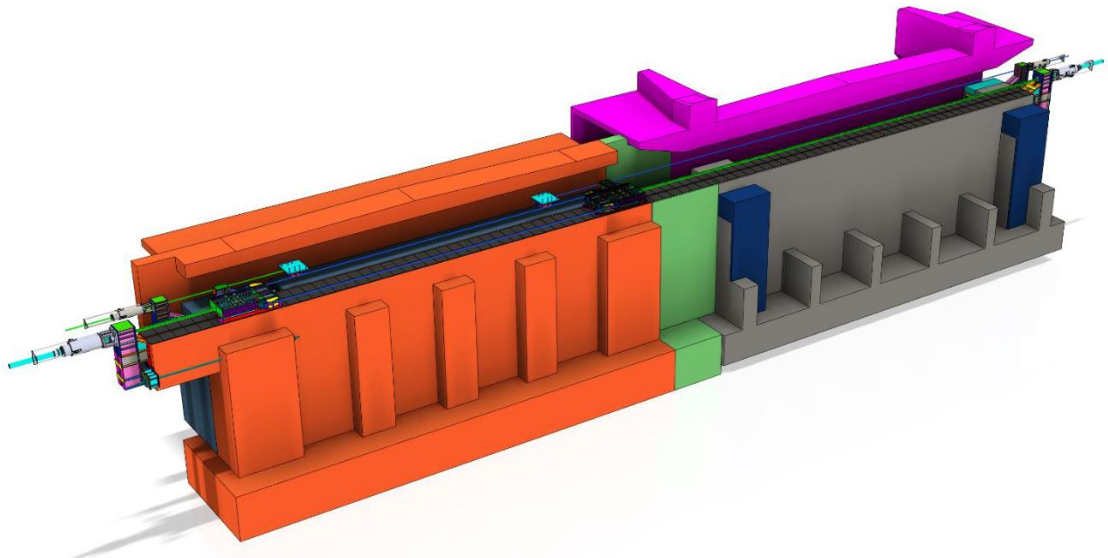
- 4 x 322 ton (VSL SLU 330) launching strand jacks plus 1 spare, including power pack and control unit;
- 4 x pulling cables, consisting of 31 strands each (15.3 mm dia, 276.7 kN UTS / strand);
- For additional pulling capacity - 2 x 120 ton (VSL SLU 120) cylinders which will be adapted by VSL to act as hollow plunger cylinders with necessary pipes to connect to main power pack and control unit.
- For additional pulling capacity - 50 mm diameter stress bar between hollow plunger cylinders and steel brackets mounted to deck;
- 50 mm diameter stress bar between temporary launch bearings;
- 4 x temporary launch bearings. Each bearing has two custom built-in 900 mm diameter pot bearings to accommodate deck rotation and construction tolerances of the sliding surfaces;
- 4 x roller side guides fixed to the temporary launch bearings; and
- 13mm thick Eberspächer sliding pads.



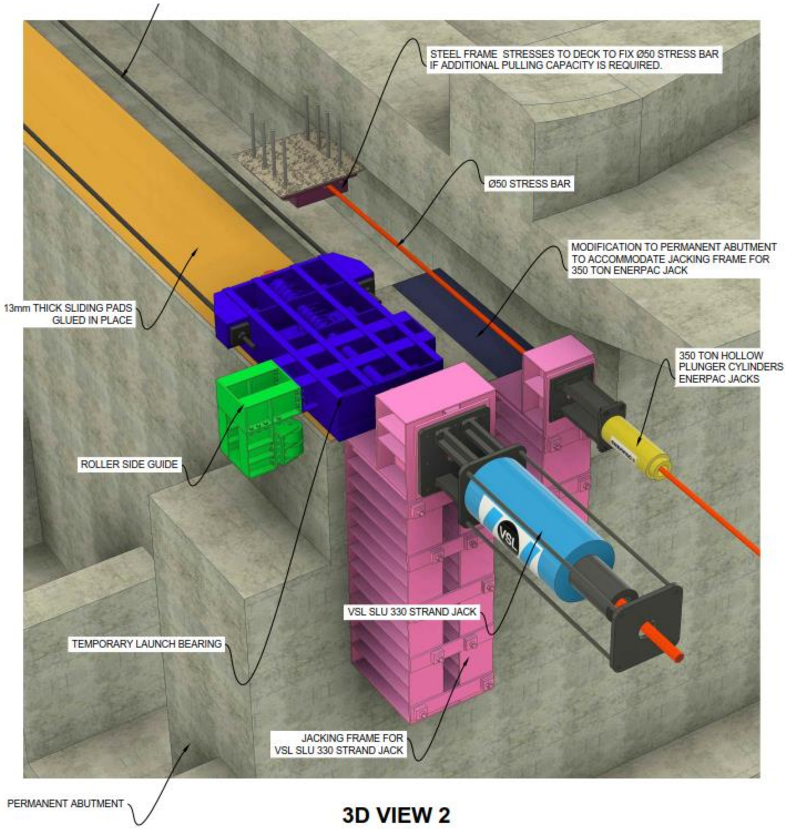
Transverse Launching

The launch designer has designed the launch according to the following basic criteria:

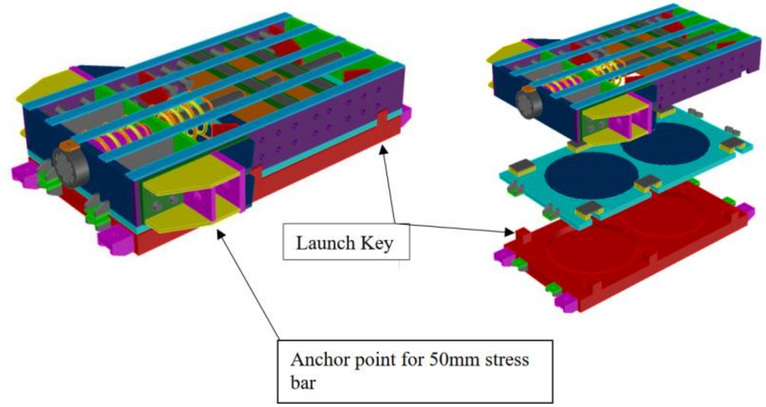
- Dead Weight of Bridge.................................. 4000t / Abutment
- Max Friction System can overcome 11.6%
- Maximum pulling capacity of system .... 4630kN / Abutment
- Pulling capacity of SLU 330t jack .... 3220kN / Abutment
- Expected starting force per increment .... 2400kN @ 6%
- Expected pulling force.................................. 1600kN @ 4%
- Max. safe force allowed before investigation required .... 3200kN @ 8%
- Capacity of system identical forward and reverse

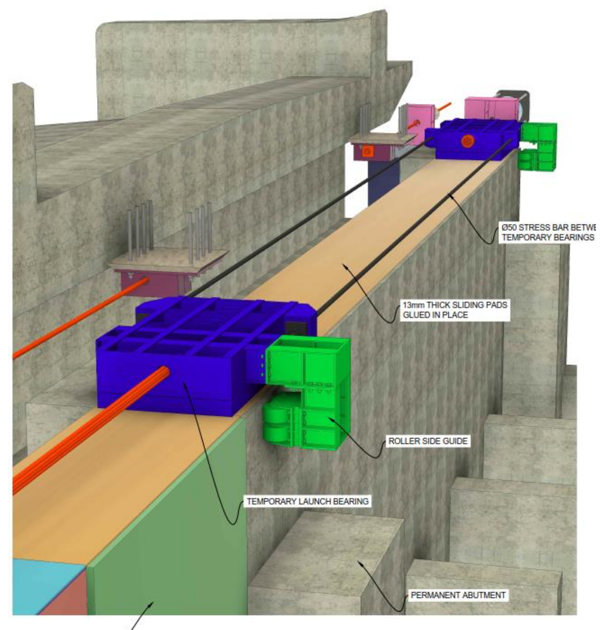


Transverse Launching



3D VIEW 2
N.T.S





3D VIEW 3
N.T.S

Acknowledgements

Client:	Western Cape Government, Department of Transport & Public Works
Local Municipality:	Langeberg Municipality
Consulting Engineer:	AECOM SA
Bridge Engineering:	AECOM SA, AECOM UK & Edward Smuts
Erection Engineering:	AECOM SA & Dave Middleton (Interim Maintenance Contract & New Construction contract Contract)
Main contractors:	Basil Read (OCC), Haw & Inglis (IMC & NCC)
Specialist Sub-contractors:	Amsteele Systems & Redaelli
	Nova Engineering Works
	Fairbrother Geotechnical Engineering
	AllWeld
Temporary Works Designers:	Form Scaff & Richard Beneke Designs
	Aurecon, Maffeis, Nyeleti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