Msikaba Bridge Inclined PT Grouting

Content

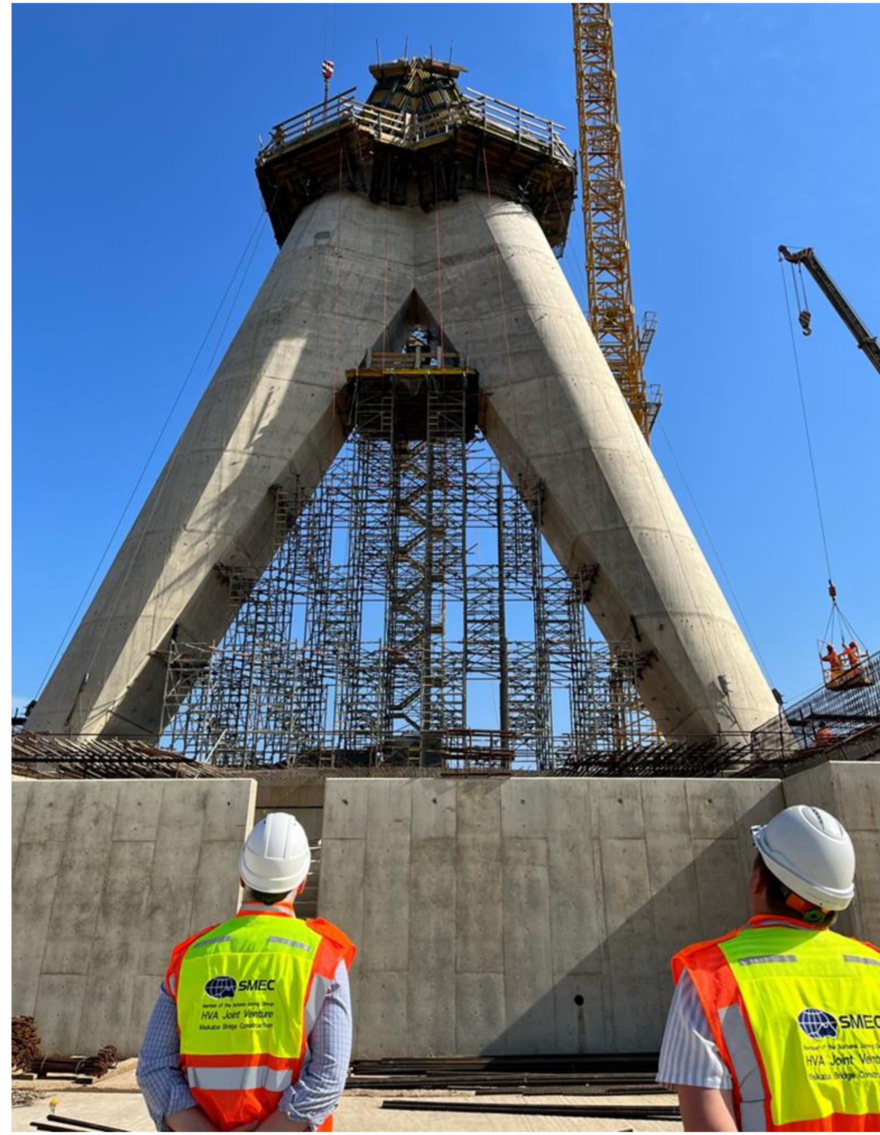
- Msikaba bridge
- Grouting requirement
- Grout trials
- Outcome

Msikaba Bridge

Msikaba Bridge

Contract Information

Design Engineers:	SMEC SA , Jacobs (formally Halcrow) and Axis - HVA JV
Supervision:	SMEC South Africa
Contractor:	Concor, Mota Engil Joint Venture - CMEJV
Employer:	South African National Roads Agency (**SANRAL**)
Value (excl VAT):	**R2 Billion** (estimated cost at completion)



Msikaba Bridge

Facts and Figures

Deck Span length:	580 m
Height above valley:	192 m
Earthworks cut:	787 000 m^3
In Rock:	470 000 m^3
Concrete:	48 500 m3
Reinforcing:	4 300 tons
Structural Steel:	2 900 tons
Cable Stay Tendons:	1 090 tons (930 km)

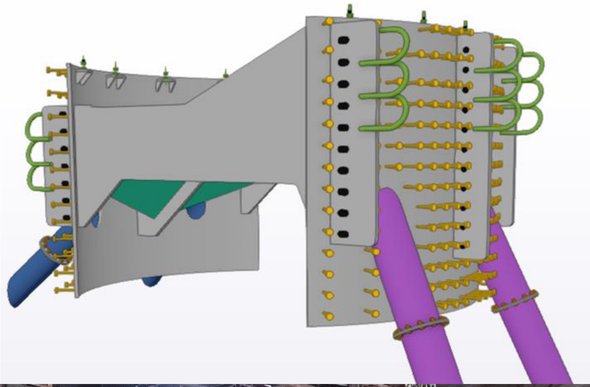
Msikaba Bridge

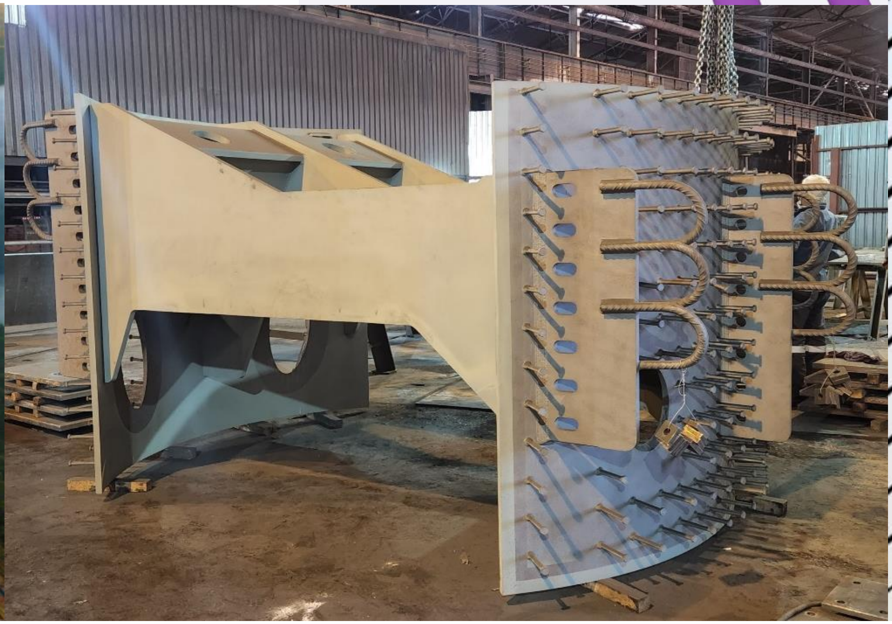
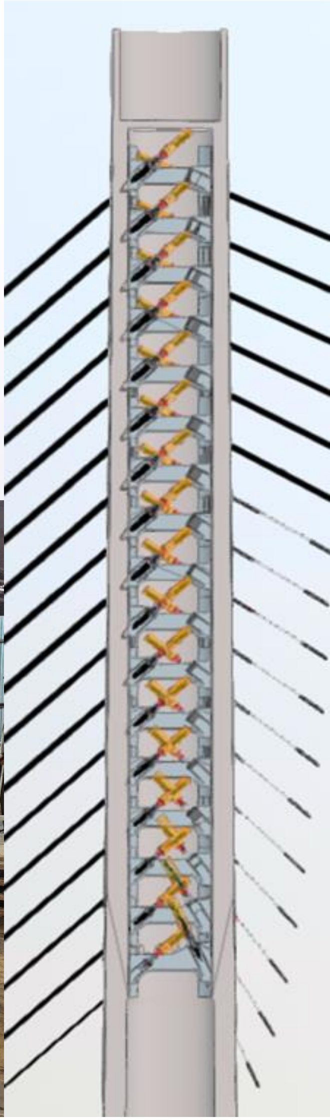
Facts and Figures

Msikaba Bridge

Pylons

- Two identical inverted Y shaped concrete pylons 127 m High
- Taper from 4.5 m diameter at the pylon head to 6 m at the top of the inclined legs.



Msikaba Bridge

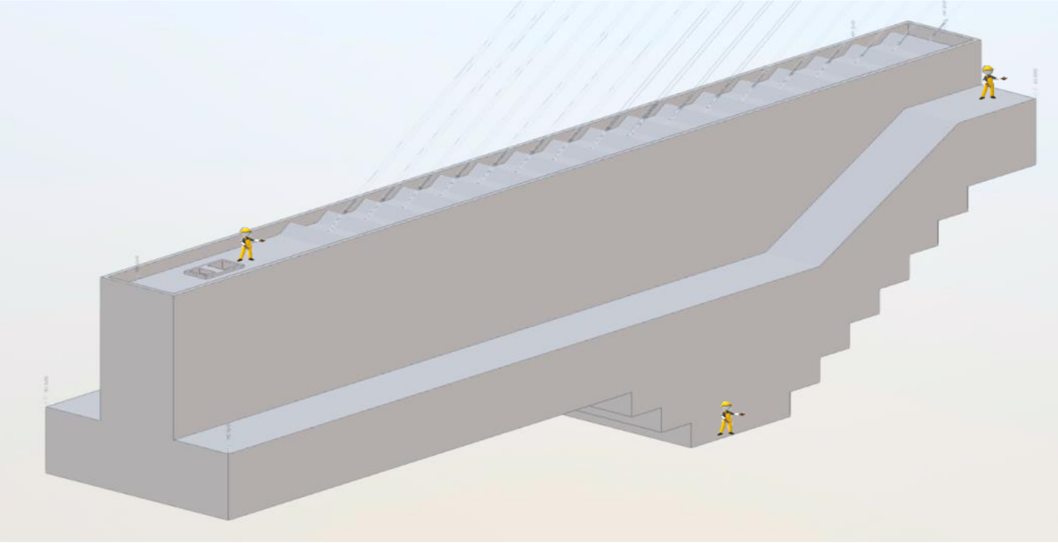
Deck

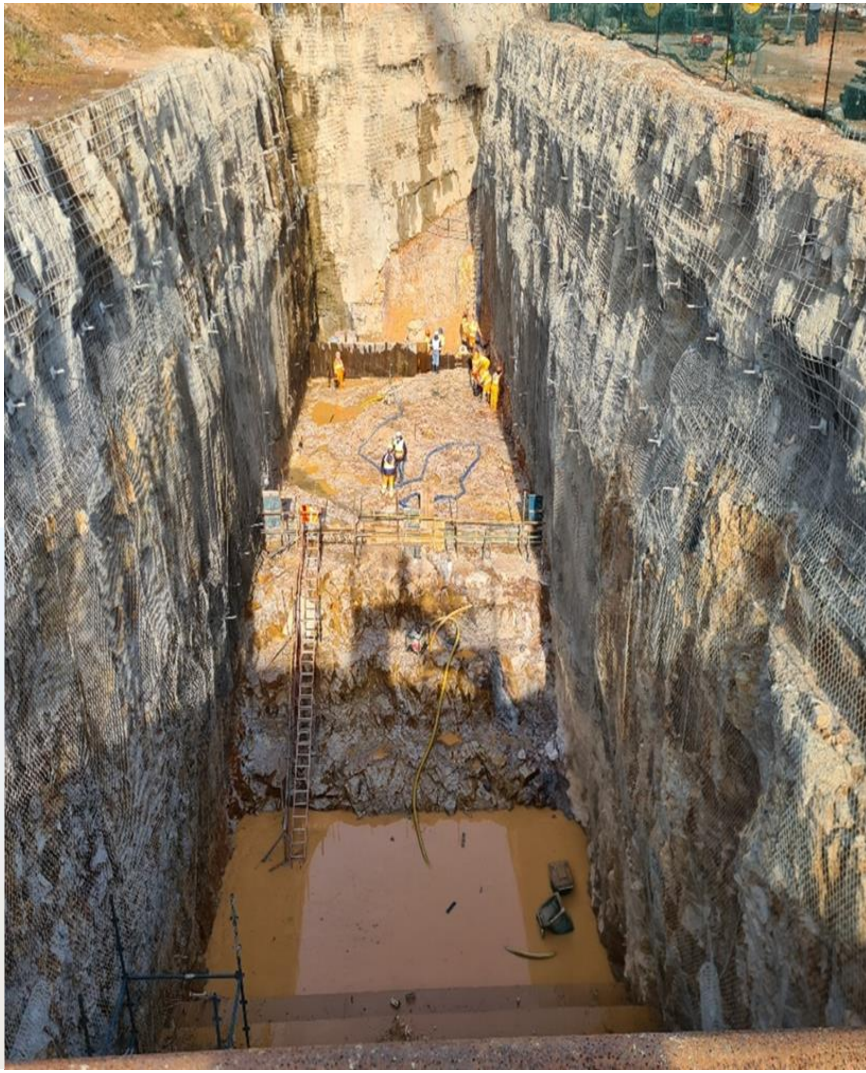
- Steel-concrete composite deck – 530m long.
- 250 mm thick in-situ reinforced concrete slab.
- Constructed from both ends.
- 17 typical deck segments 15m long each side.

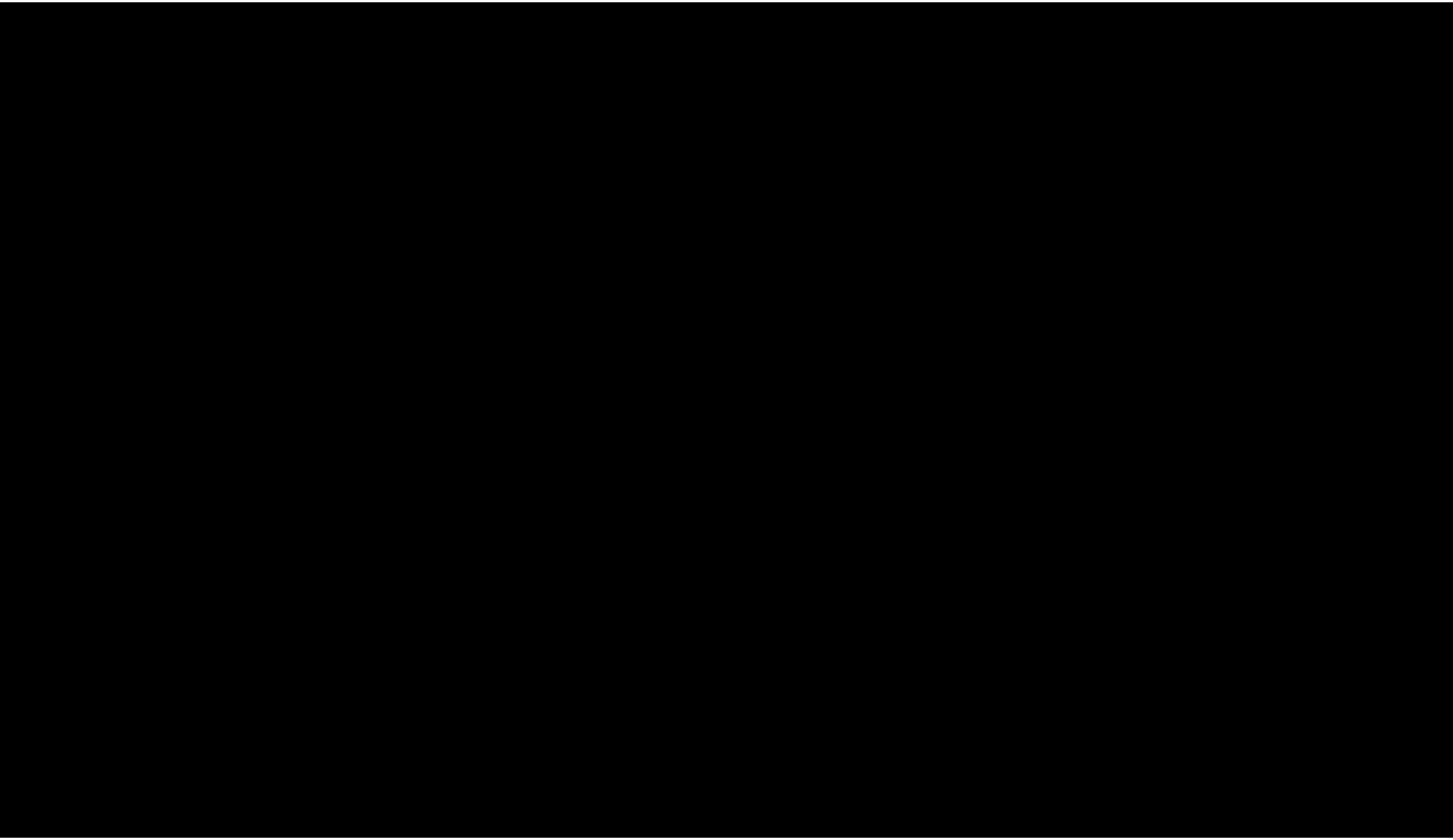
Msikaba Bridge

Anchor Blocks

- Buried concrete gravity anchors
- Size of 49 m long x 10 m wide x 17 m deep
- 15 500t each



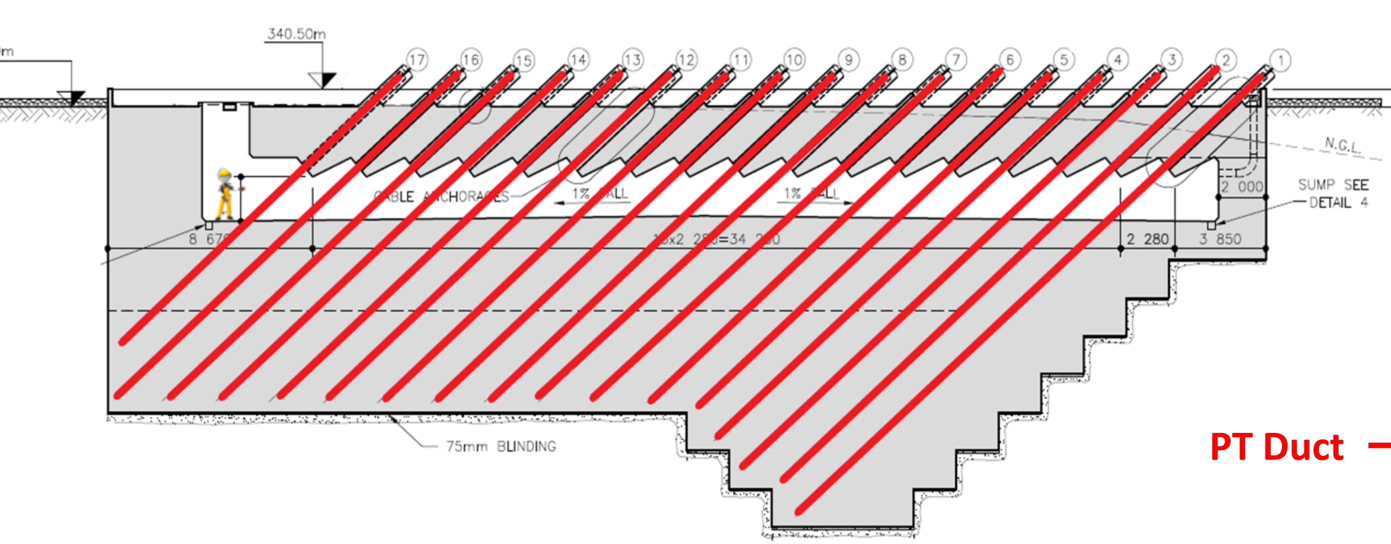


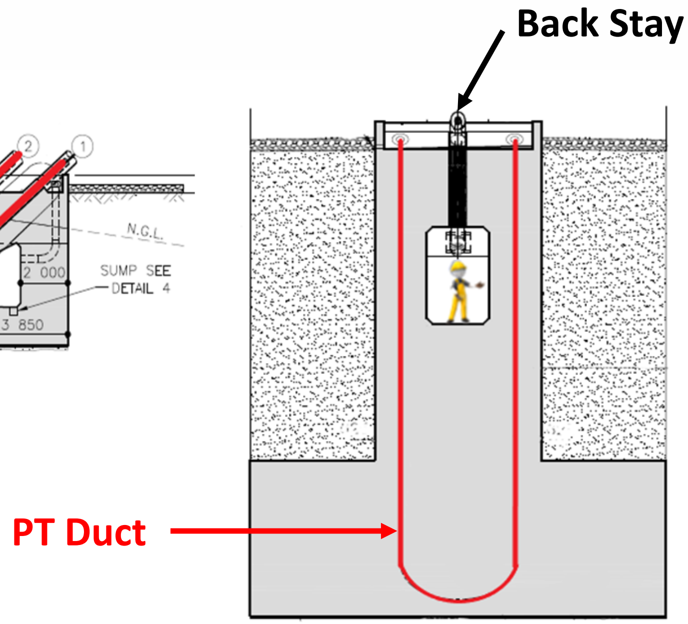


Grouting Requirement

PT in Anchor Blocks

- U-shaped prestressing tendons extending to the full depth of the anchor block.
- Provide structural capacity, anchoring the stay cable anchors securely to the full depth of the anchor block structure.
- Inclined at 41° and 16,5 meters vertical height

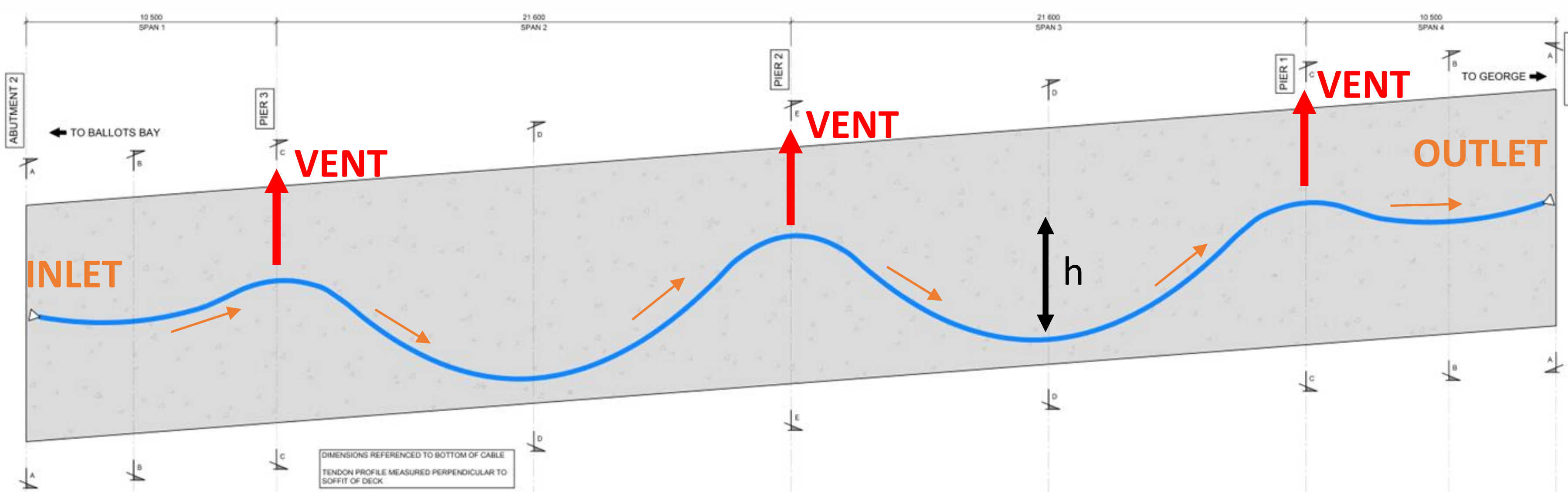




Grouting Requirement

Conventional Tendons

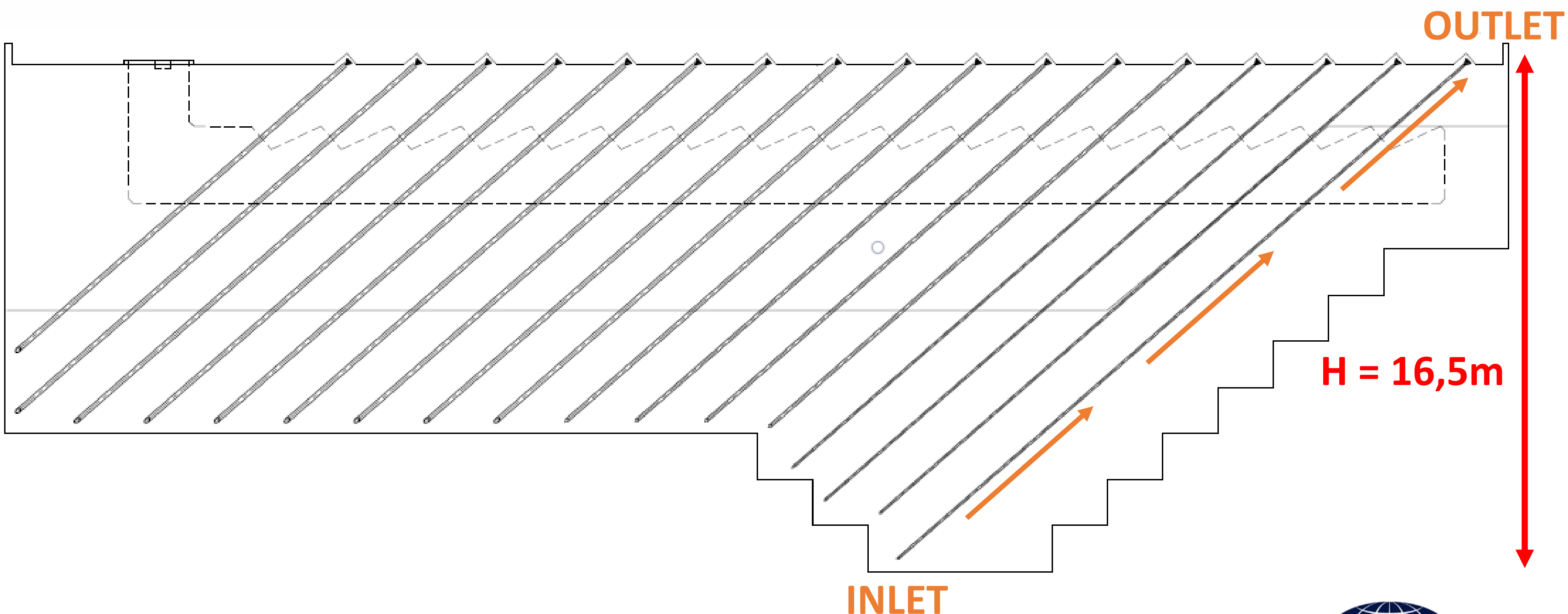
- Traditionally beam structures
- Relative small elevational changes (h) in tendon profiles
- Negligible differential hydrostatic pressure in uncured grout – little to no bleed water
- Grout properties and testing well established with EN 445 and EN 447



Grouting Requirement

Msikaba Tendons

- Unconventional structure and PT in SA
- Significant elevational changes (h) in tendon profiles
- Significant differential hydrostatic pressure in uncured grout (Settlement, bleed)
- Grout properties and testing not conforming to EN 445 and EN 447



Grouting Requirement

Msikaba Tendons - Challenges

- Bleed water control/management?
- W/C Ratio?
- Pressure gradient – effect?
- Lack of reabsorption of bleed water
- Workability vs setting time
- Repeatability/robustness
- Compressive strength

→ **Full Scale Trials!**

Grout Trials

Purpose

- Ensure high quality bonded tendons
- Durability of structure
- No access to tendons in future
- Simulate longest tendon with maximum curvature and steepest incline (41°)
- To test equipment, methodology and operators

Grout Trials

Basic Overview

- Earth fill embankment constructed
- Grout mixed and pumped from above inlet.
- Grout injected from lower end of tendon.
- Smooth duct vs Corrugated duct
- 7 strand anchor – stressed to 10ton
- After curing, samples cut and assessed.
- Findings used to refine methodology.

Grout Trials

Material vs Methodology

- Bleeding phenomena - Control or manage
- 2 ways: material performance and/or methodology

Grout Trials
Material

- W/C ratio
- Position of pump - grout flow in direction of pressure gradient
- Reduced W/C ratio possible
- Reduced flow times possible
- Independent grout material trials conducted
- Measure bleed affected grout

Grout Trials

Material

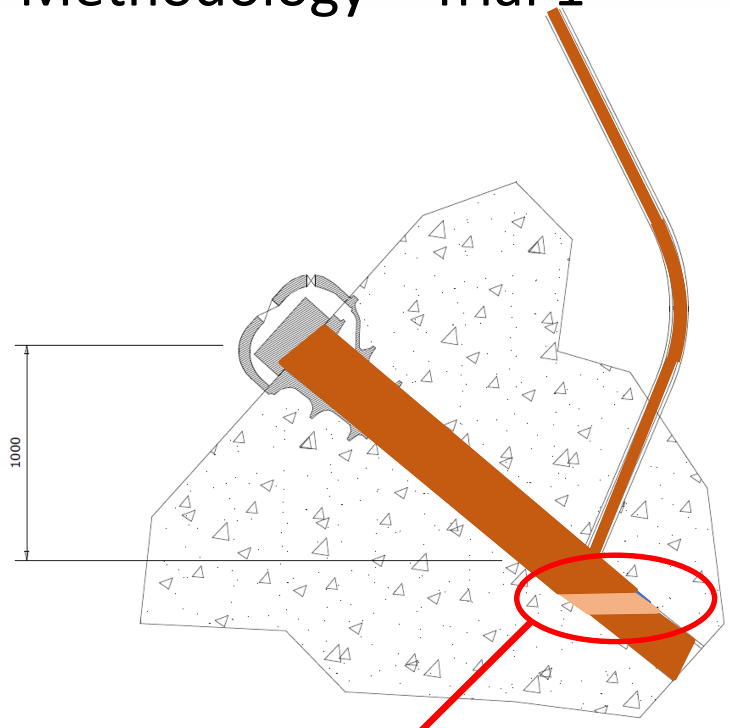
Grout Trials

Methodology – Trial 1

- 7 strand anchor fully occupied
- Reinjection valve added below anchor
- Inject grout
- Apply vacuum pump (1 hour)
- Apply air at grout cap to evacuate grout via reinjection pipe
- Cure 24 hours
- Blow out
- Re-grout

Grout Trials

Methodology – Trial 1



- -Injection
- -Evacuation
- -24 hours curing
- -Blow out
- -Reinjection

FAIL:

Blow out cannot eject bleed affected grout

Grout Trials

Methodology – Trial 1

Grout Trials

Methodology – Trial 2

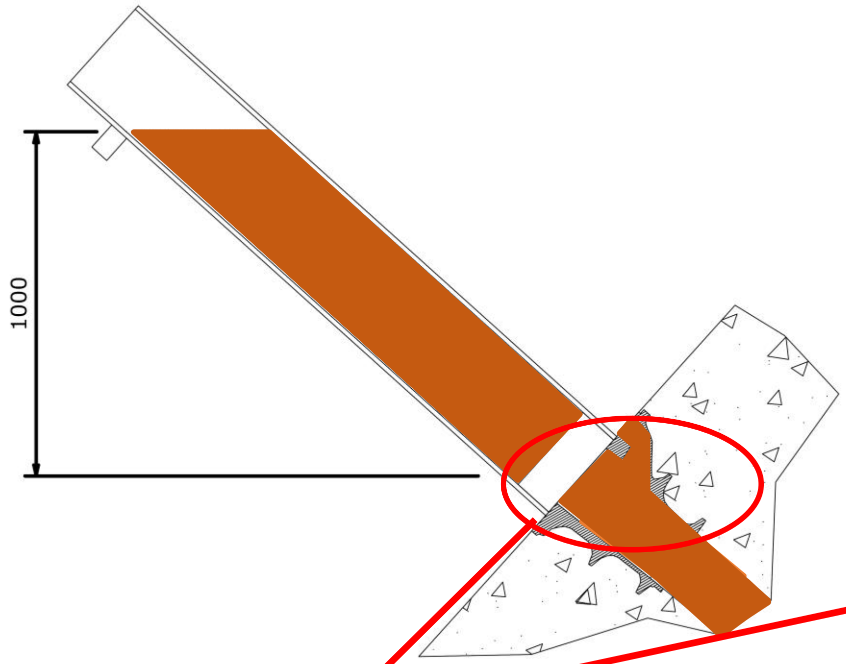
- 7 strand anchor fully occupied
- Add reservoir to accommodate bleed affected grout
- Inject grout
- Cure 24 hours

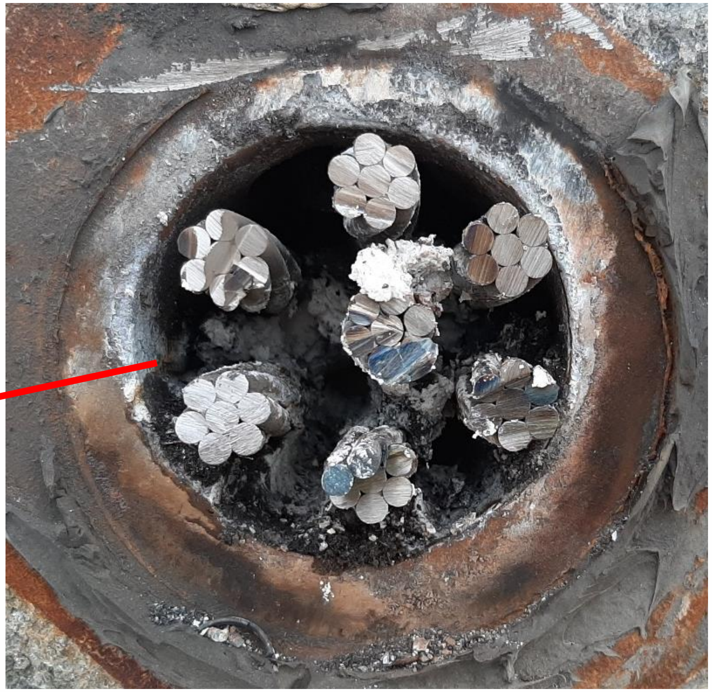
Grout Trials

Methodology – Trial 2

-Injection

-24 hours curing



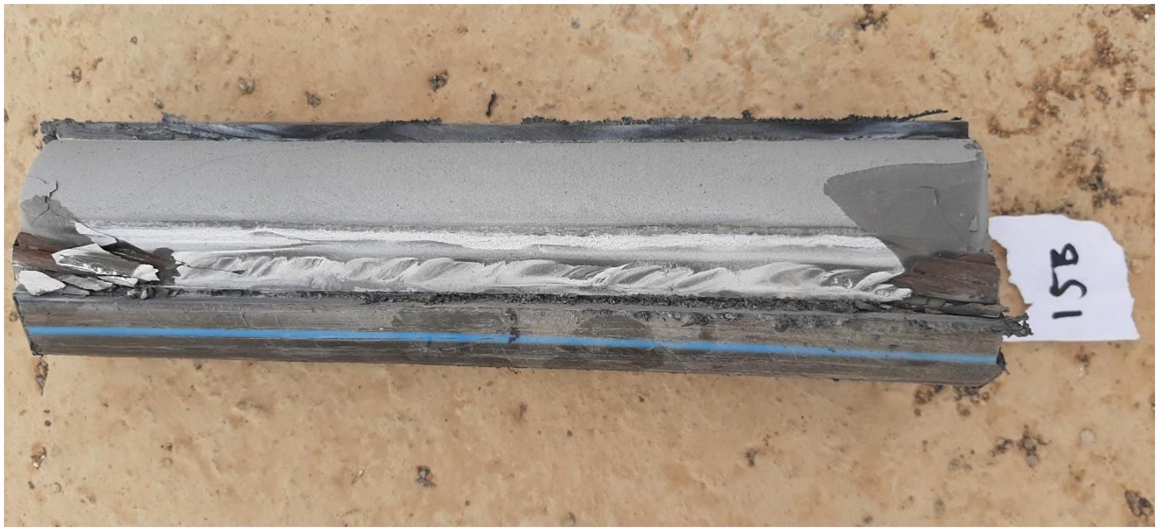


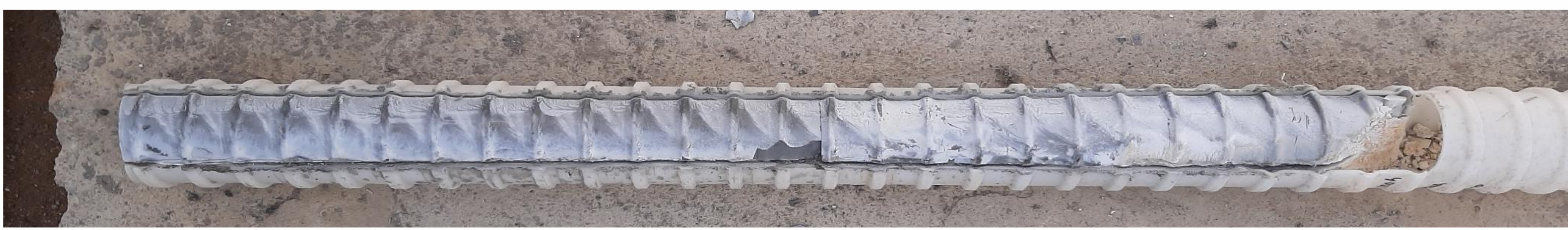
FAIL:

Anchorage prevents migration of bleed water to reservoir

Grout Trials

Methodology – Trial 2





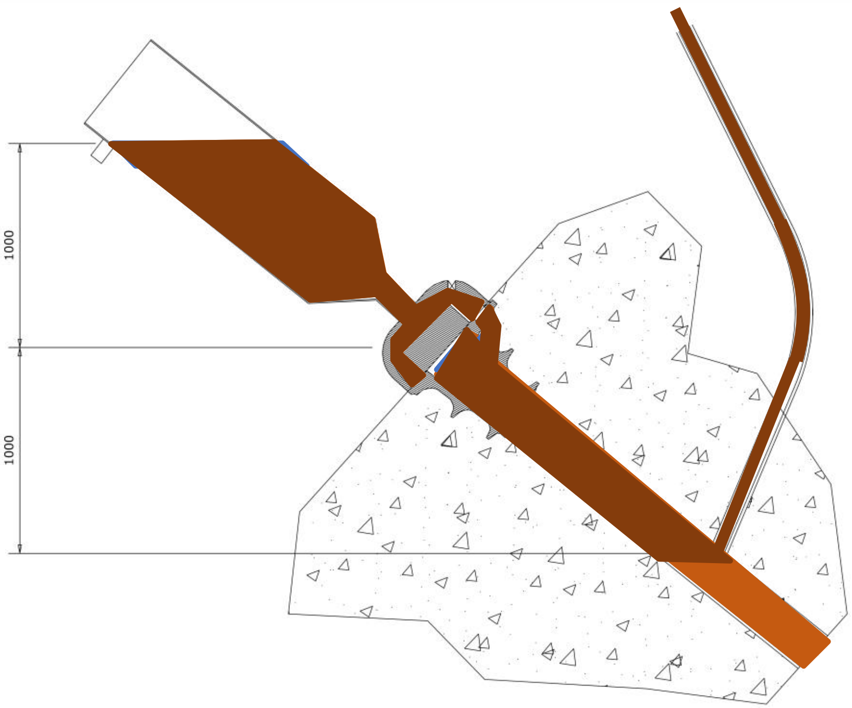
Grout Trials

Methodology – Trial 3

- 7 strand anchor fully occupied
- Add reservoir to accommodate bleed affected grout
- Add grout cap for clear bleed water migration path
- Inject grout
- Reinject after 2 hour period
- Cure 24 hours

Grout Trials

Methodology – Trial 3



-Injection

-Wait 2 hours

-Reinject

-24 hours curing

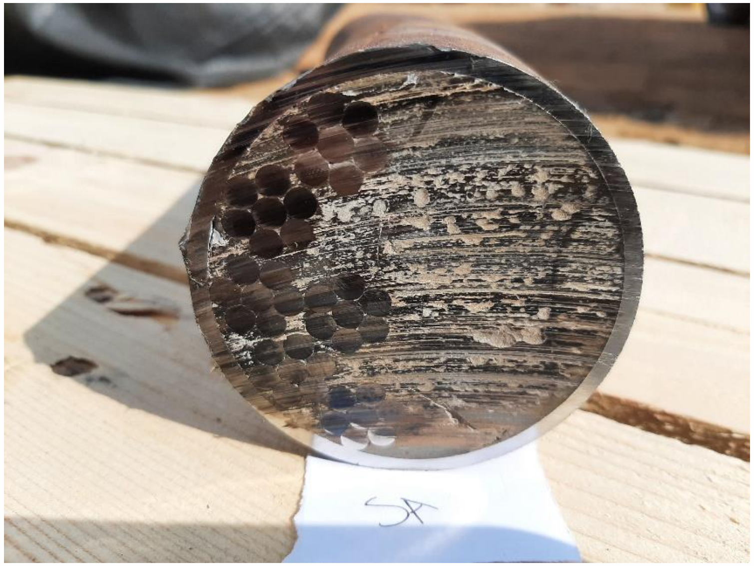
SUCCESS

Grout Trials

Methodology – Trial 3

Grout Trials

Methodology – Trial 3



Conclusion

- Bleed water can be managed by both material and methodology
- Clear migration path for bleed water through anchorages vital
- Reinjection at top of tendon before initial grout sets.
- Workability not affected by lower W/C ratios.
- Slower flow times had no effect on quality and filling ability
- Success through local products combined with local experience

Thank you