IMGC

LA DURABILITÉ DE LA PRÉCONTRAINTE EXTÉRIEURE

Journée Technique
Vendredi 27 septembre 2018
FNTP – 3 Rue de Berri, 75 008 PARIS

AFGC
Association Française de Génie Civil

HAMMERSMITH Flyover Post-Tensioning Repair Overview, the British Approach

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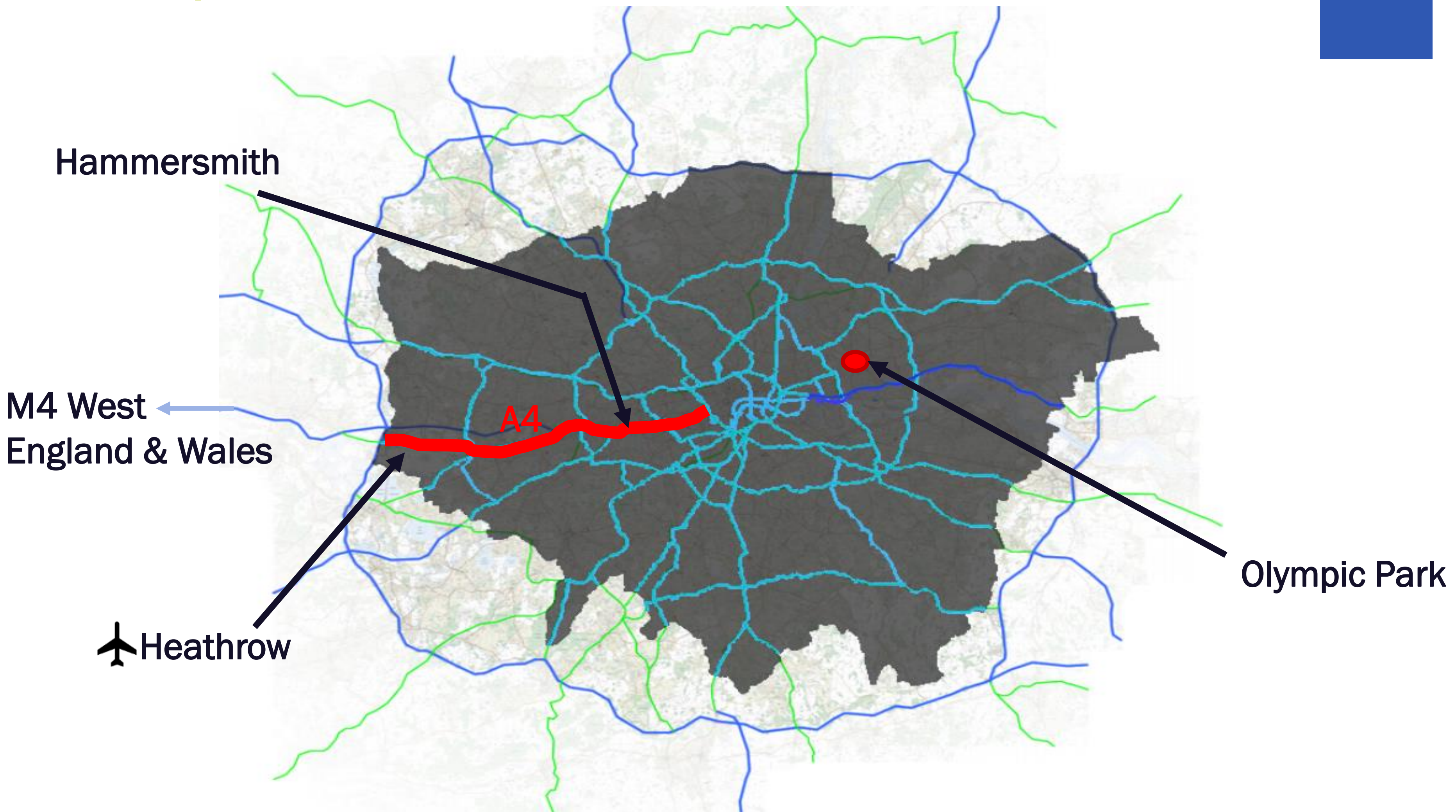
Hammersmith Flyover Importance

Transport for London Road Network



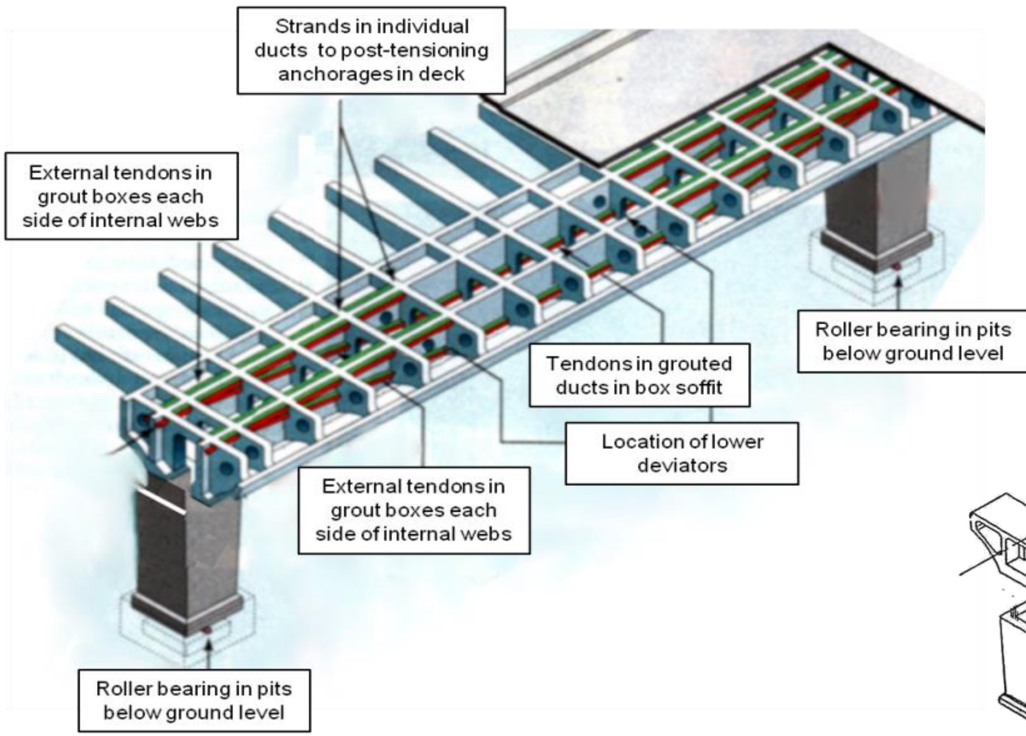
Hammersmith Flyover Importance

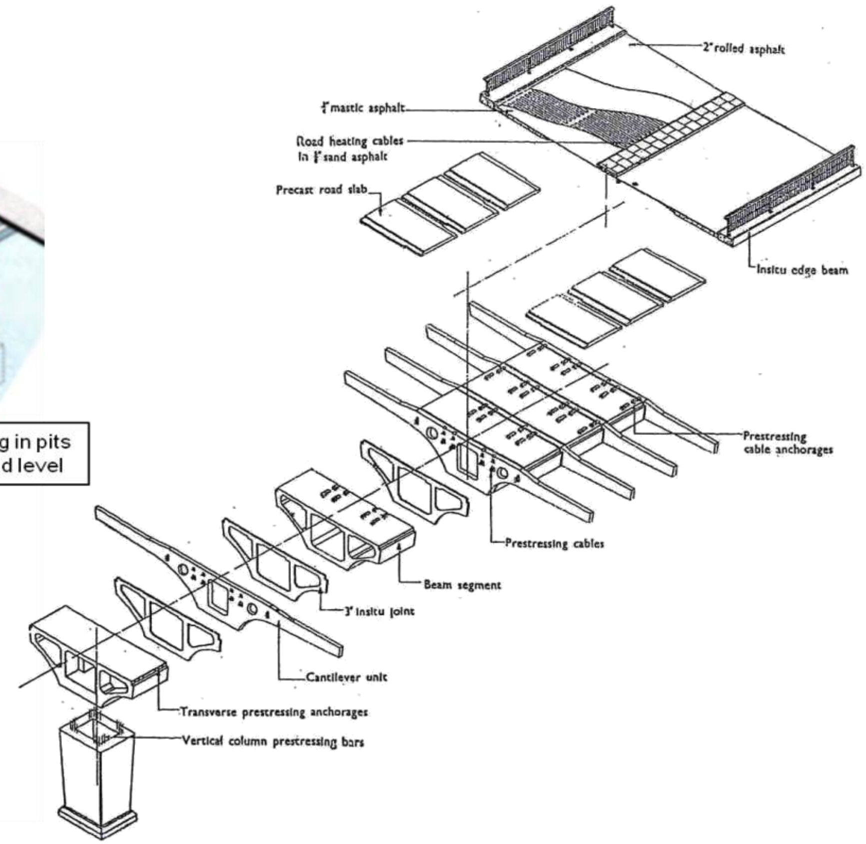
Transport for London Road Network

- 16 spans
- 622m elevated length
- Max box depth 2.75m
- Min box depth 1.98m
- Typical span = 42m
- 80,000 vehicles / day
- Post-tensioned pre-cast
- Bridge Owner-Transport for London (TfL)

Technical Specifics

Structural Form



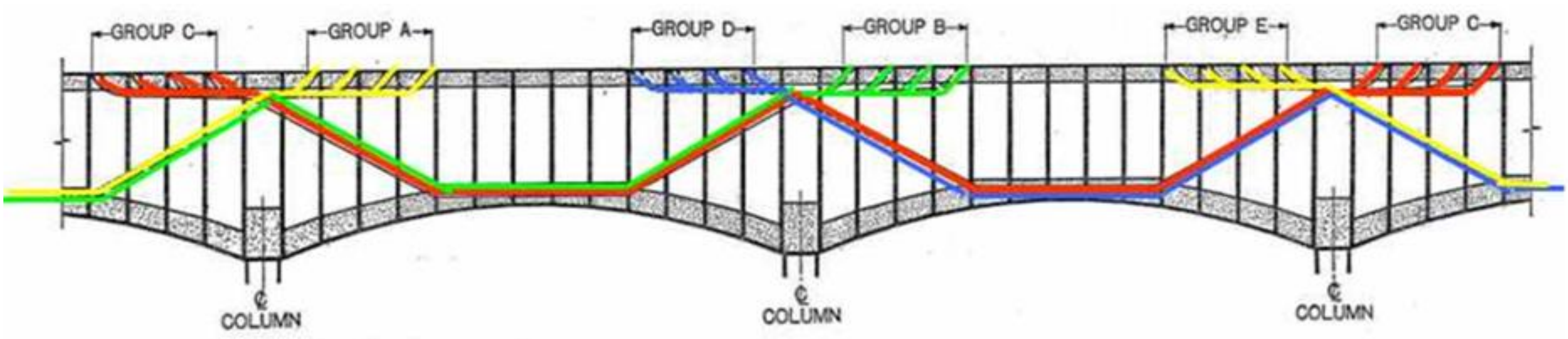


Technical Specifics

Structural Form

Technical Specifics

Original Prestress Layout



- Sloping sections are external to concrete section in “grout boxes”
- Mid span sections grouted in 4 large ducts (12 strands)
- Individual grouted strand at anchors
- 19 Wire Strand

Prestress Deterioration

Timeline (1)

1961	Hammersmith Flyover opened
1962	Heated road surface decommissioned
1990s	PTSI programme commenced
Late 1990s / Early 2000s	Works to reduce water ingress – manholes sealed and rewaterproofing
Late 2000s	Intensive PTSI and assessment (40T)
2010	Installation of monitoring
2011	Propping installed on one critical span
23rd Dec 2011	Flyover closed to all traffic

Prestress Deterioration

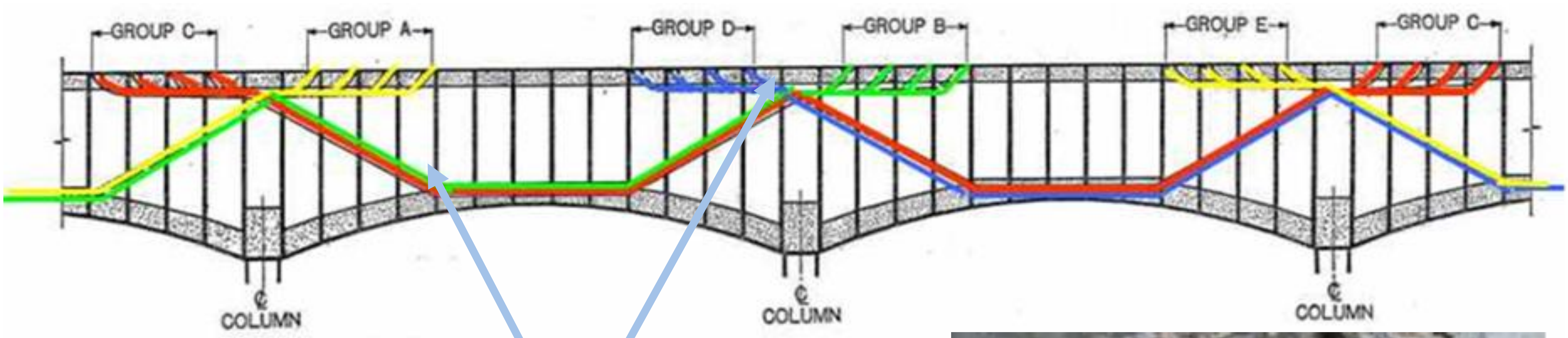
Condition of Tendons

Prestress Deterioration

Condition of Tendons

Prestress Deterioration

Corrosion Locations



Corrosion concentrated at transition from external in “grout boxes” to conventional internal

Prestress Deterioration

Timeline (2)

7th Jan 2012	Flyover opened to 7.5T vehicles
23rd Dec 2011	Flyover closed to all traffic
7th Jan 2012	Flyover opened to 7.5T vehicles (2 lanes)
Jan – May 2012	Phase 1 strengthened constructed to partially strengthen 5 spans
30th May 2012	Flyover fully reopened to all traffic (40T)
27th July 2012	London 2012 Opening Ceremony
Late 2012	Phase 2 strengthening project commenced

Monitoring & Investigation

Methods Used

Acoustic Emission	Intrusive Investigation
▪ Very Effective	▪ Targeted at specific locations
▪ Did not work during Phase 1 (emergency partial strengthening)	▪ Identified that virtually all failures at interfaces
▪ Filtering now improved	▪ Cannot see all wires
▪ Only tell you changes; not what has occurred already	▪ Results have to be extrapolated

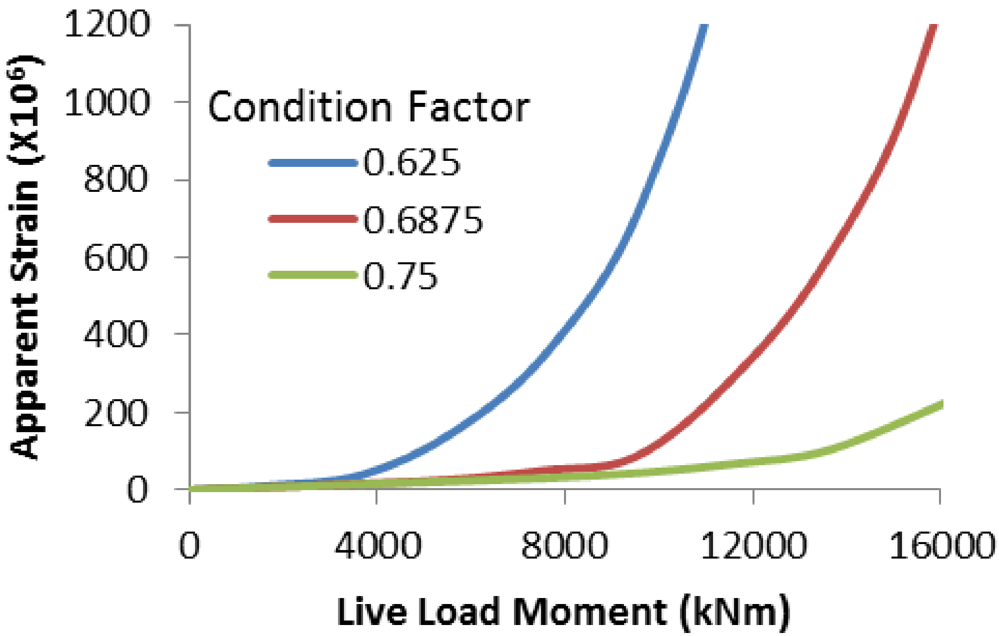
Monitoring & Investigation

Risk – Prestress eventually becomes completely ineffective

- Need to ensure it is safe in the meantime
- Determine:
  - Current Condition Factors; how much of the original prestress is effective
  - Estimated deterioration rate and hence future Condition Factor
- Lower bound approach; same factor applied to whole unbonded length
- We know some rebonding occurred

Monitoring & Investigation

Indirect Methods – Monitoring Strain (less accurate)



Gauges span two in-situ joints

Prestress Replacement

Client Technical Requirements

- 120 years design life for all new construction
- 60 years residual life on existing structure
- Existing PT system redundant
- New PT to be replaceable
- Design to contemporary design standards/codes
- Use of Building Information Modelling (BIM)

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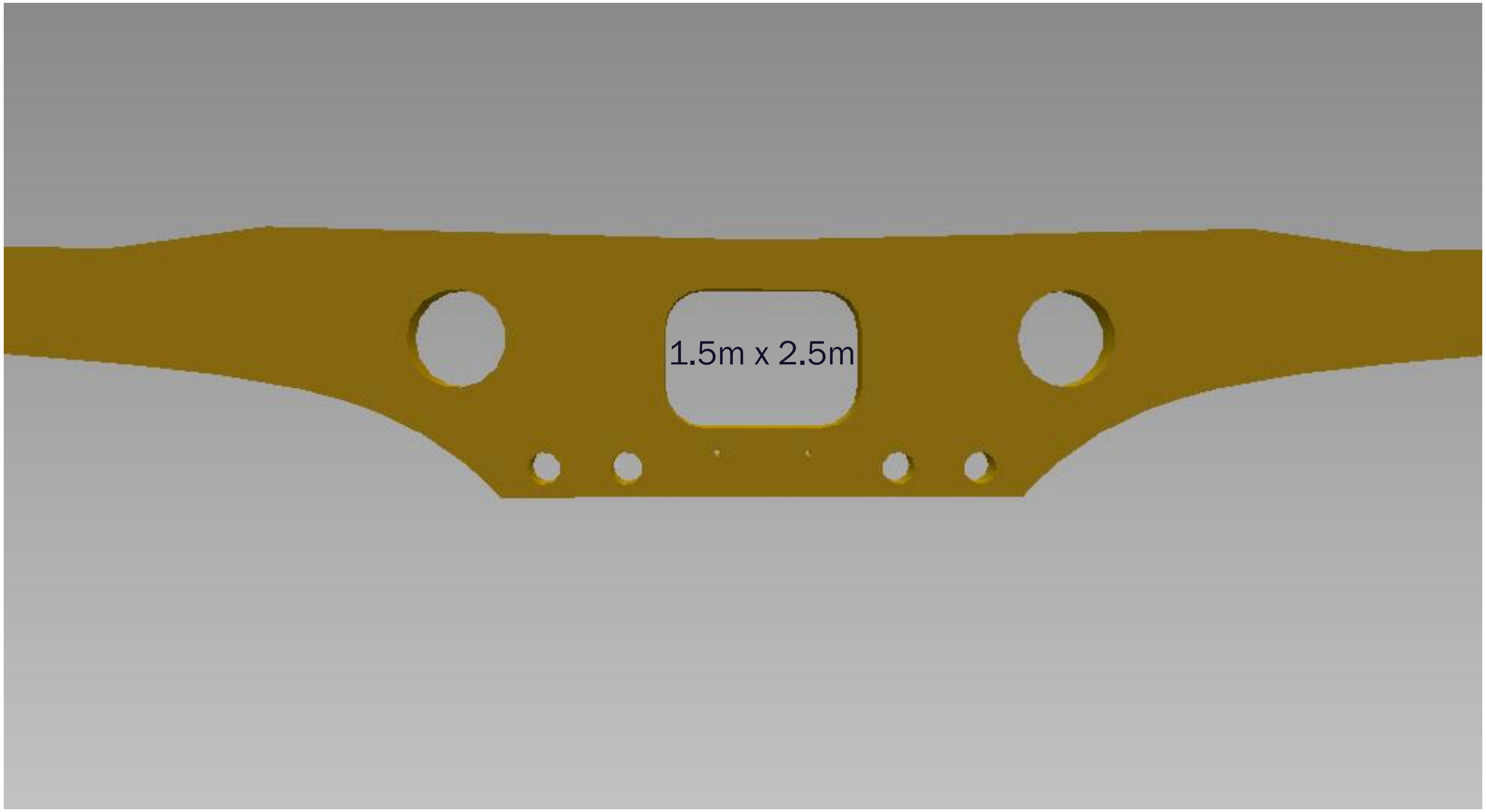
Prestress Replacement

Summary of Key Challenges

- Critical London arterial route – Roads above and below must remain open during works
- Highly constrained site with high density residential, commercial, community and transport
- Limited geometry – internally and externally
- Allow full future replacement

Prestress Replacement

Geometry – Internal & External



Prestress Replacement

Geometry – Highway Clearances

Prestress Replacement

Keep London Moving

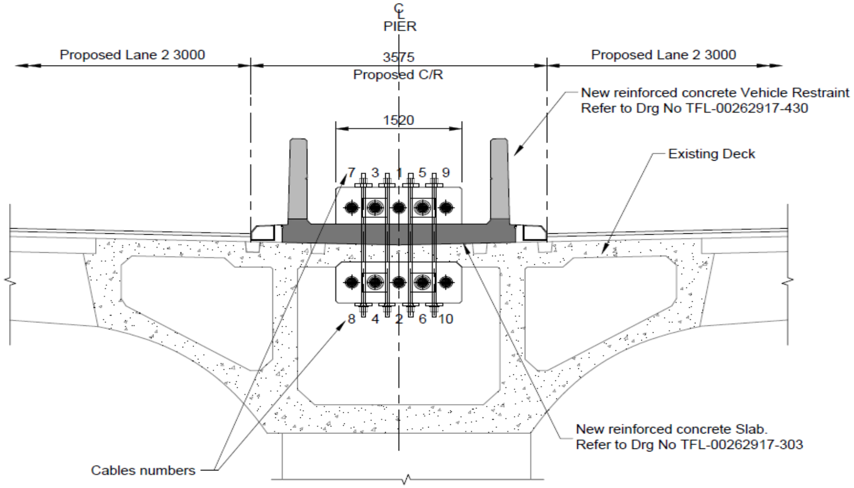
Prestress Replacement

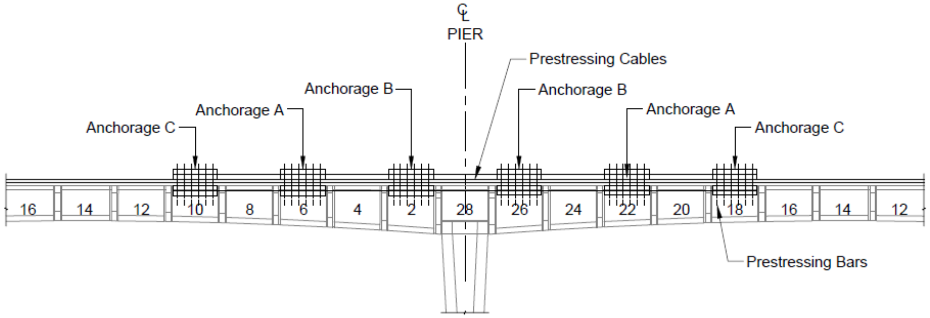
Location

Prestress Replacement

Phase 1 Stengthening

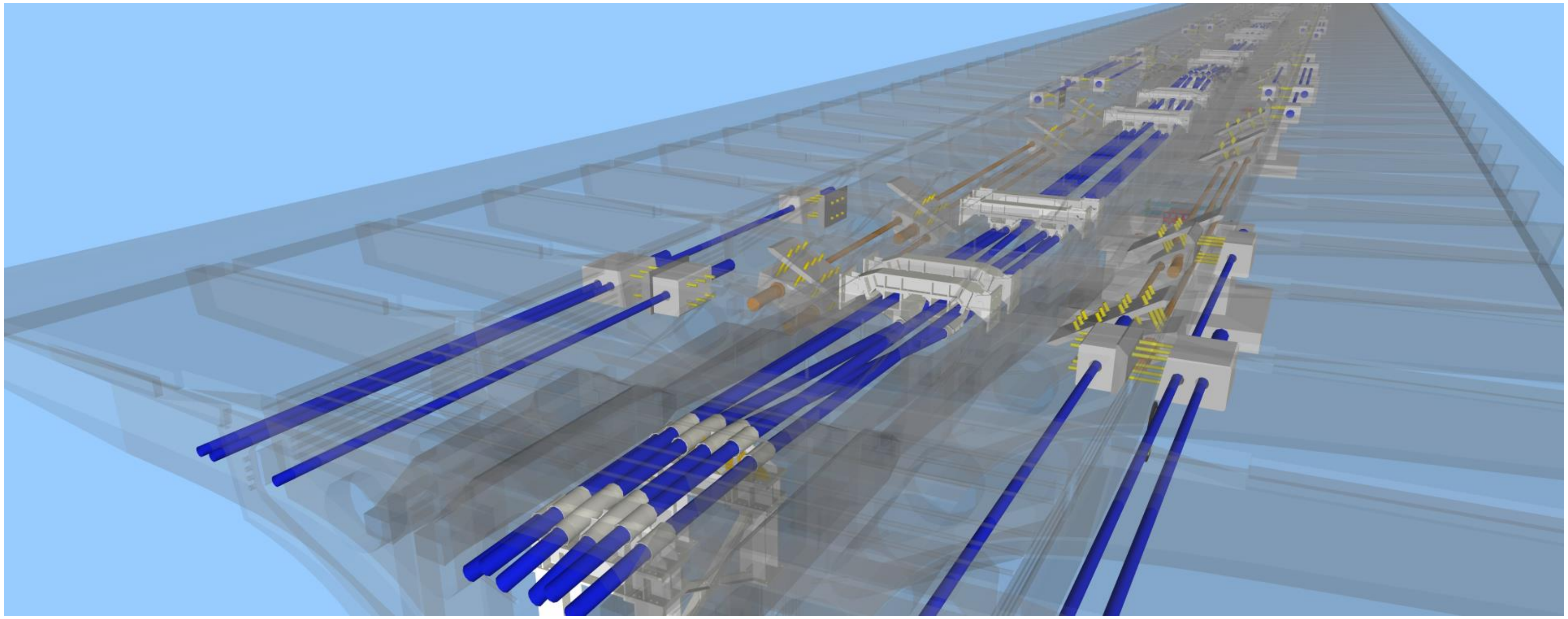
- Emergency strengthening of the 5 worst affected piers before London Olympics.
- Ramboll not involved.
- Road closures needed.





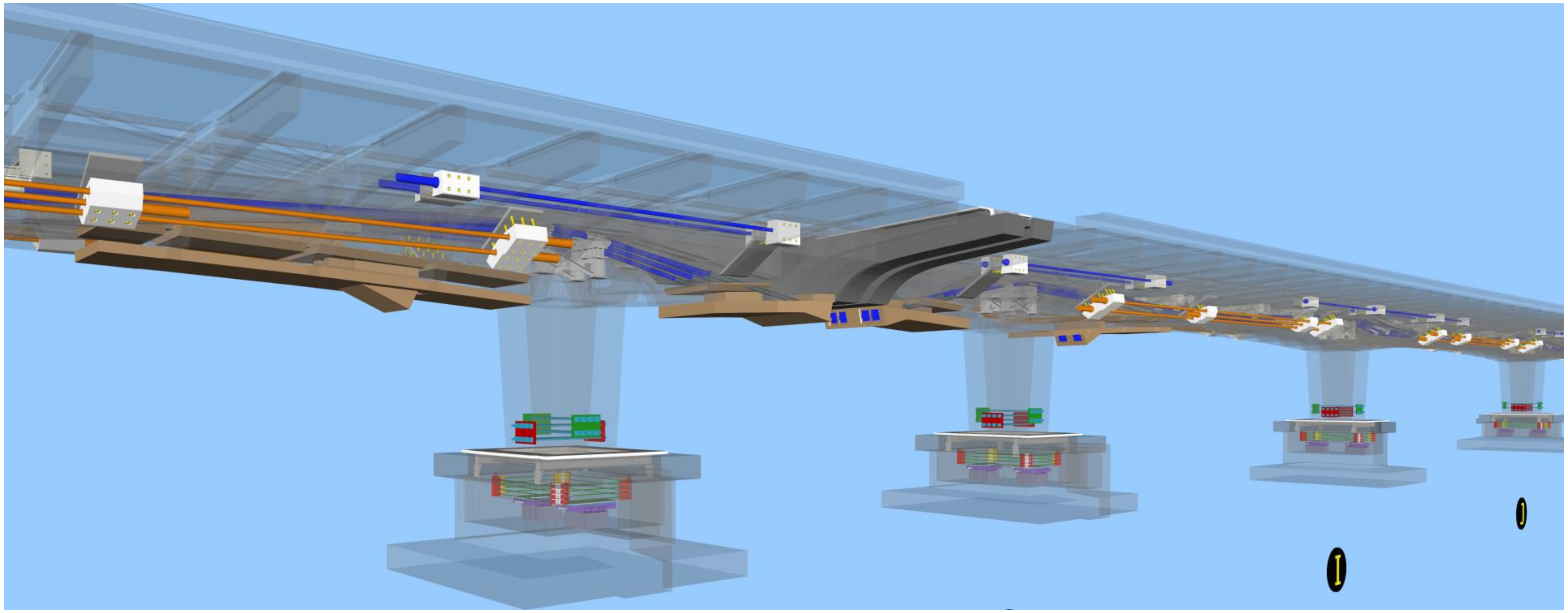
Prestress Replacement

Phase 2 Strengthening Concept



Prestress Replacement

Phase 2 Strengthening Concept



Prestress Replacement

Short Tendons – System

- PROBLEM – Cannot use grouted system.
- Grout installed before tendons stressed; temporary propping of tendon needed until tendons stressed; busy gyratory system; long term road closures <u>not an option</u>.
- SOLUTION – Use un-grouted, incrementally installed strands!

Prestress Replacement

Short Tendons – System

- 7-Wire Strand; fpk = 279kN
- Midspan Tendons = 22 Strands
- Capping Tendons = 13 Strands

Corrosion Protection

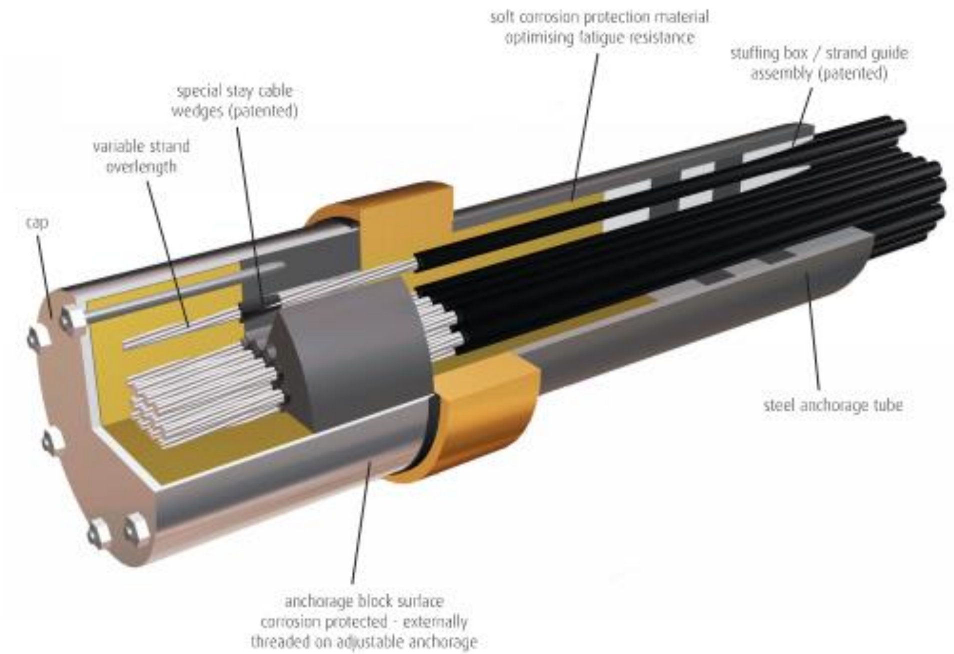
- Hot dipped galvanised strands
- Semi-bonded extruded polyethylene sheath
- Space between wire and sheath filled with petroleum wax

Or (Cohestrand)

- Hot dipped galvanised strands
- Bonded extruded polyethylene sheath
- Space between wire and sheath filled polybutadiene resin

Prestress Replacement

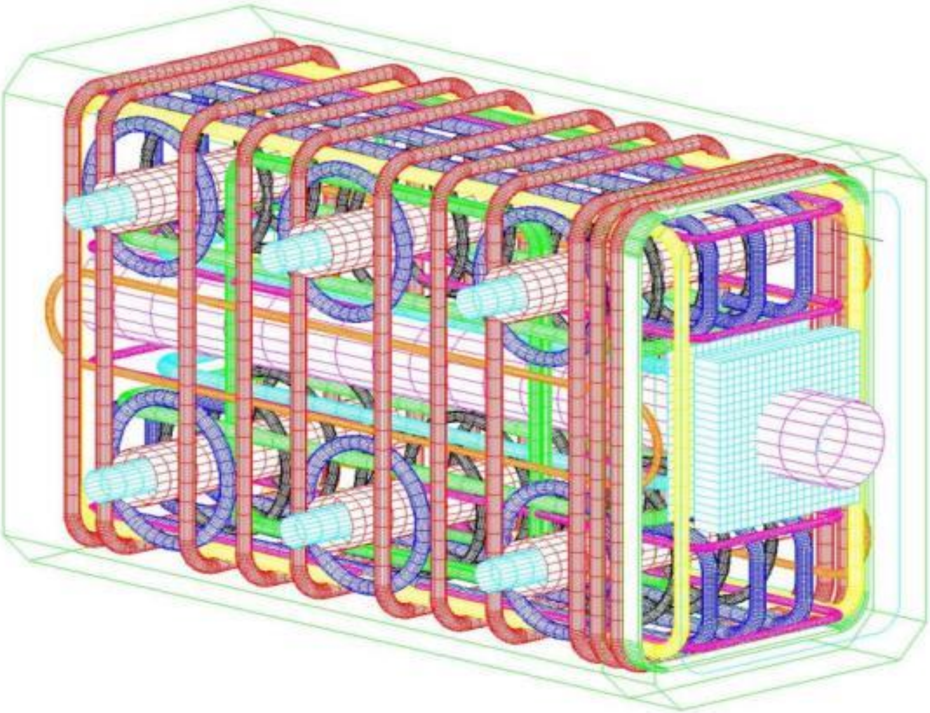
Short Tendons – Cable Stay Technology Anchorage



Prestress Replacement

Short Tendon – Blister Design

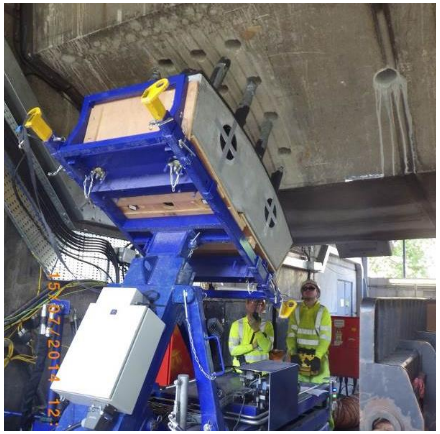
- Reinforced concrete anchors would have rebar crowding & tolerance problems
- Phase 2 blisters are more complicated and need to be more compact.
- PROBLEM!



Prestress Replacement

Short Tendon – Blister Design

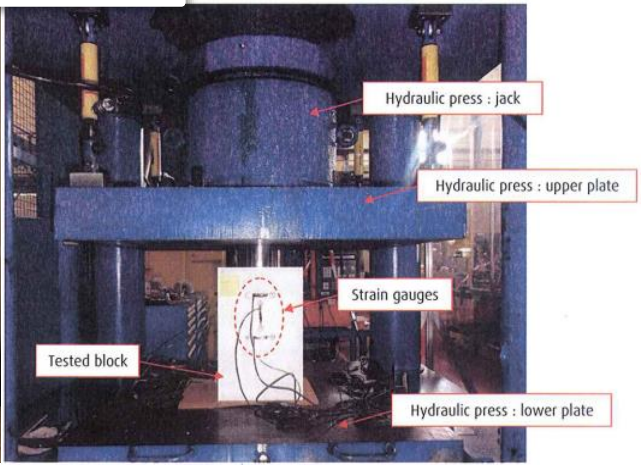
- Ultra High Performance Fibre Reinforced Concrete (UHPFRC) – Ductal©
- Very high compressive strength 130N/mm2; Tensile strength 10N/mm2.
- Unreinforced enabling lighter, more compact shape.
- Improved installation safety & maintained clearances.
- Avoided the reinforcement fixing tolerance and congestion experienced on Phase 1.
- Little design guidance; designed by testing.



Prestress Replacement

Short Tendon – Blister Design

- Prestress anchor (bar and tendon) load transfer testing.
- Confirmation of behaviour of blister anchor zones when stressed.
- Test-bed constructed in Freyssinet factory.
- Near full scale testing of complete blister and friction interface.
- Flat jack used to replicate tendon jacking force.



Prestress Replacement

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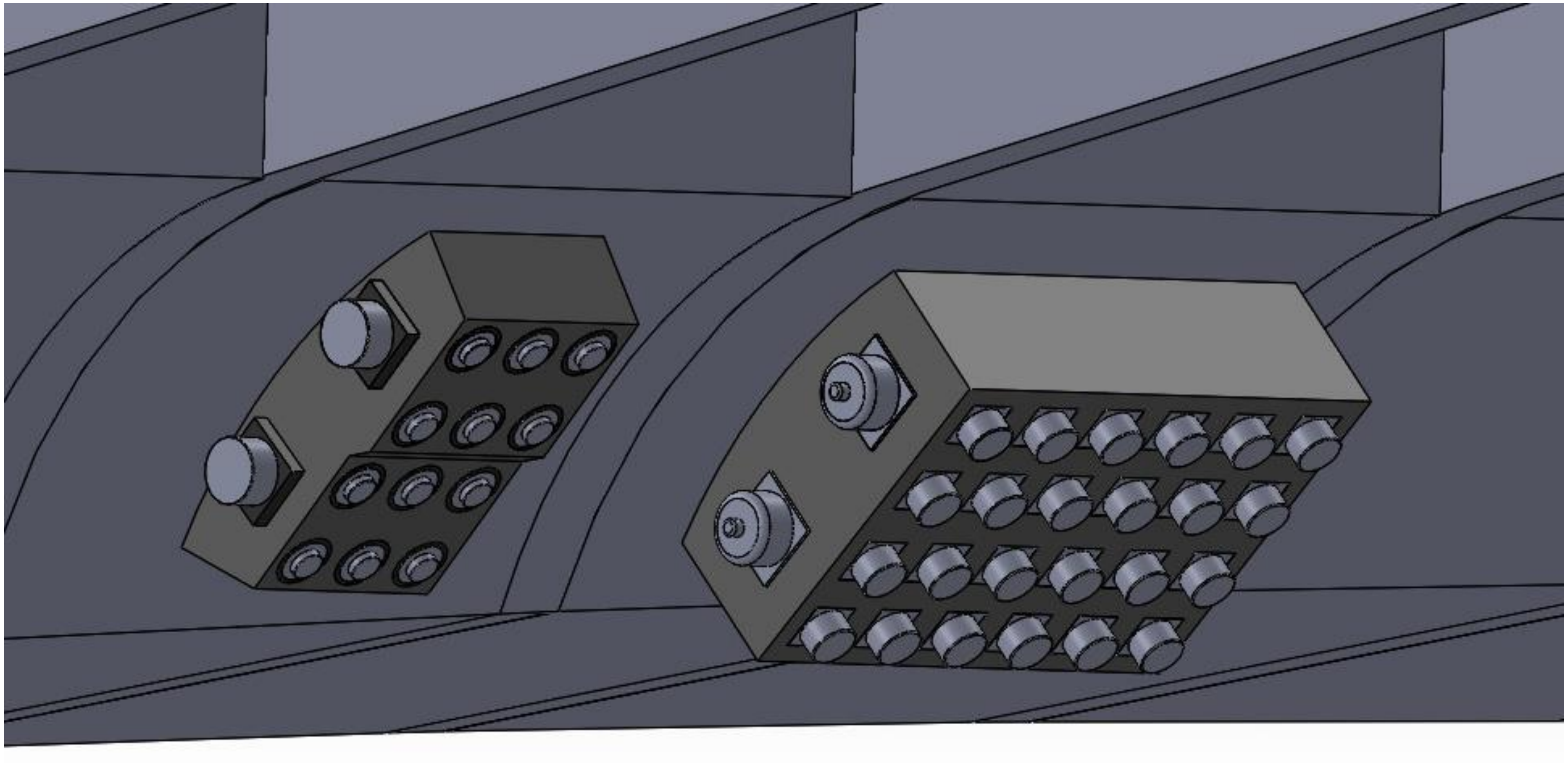


Prestress Replacement

Short Tendons – System

Blister Post-Tensioning Bars

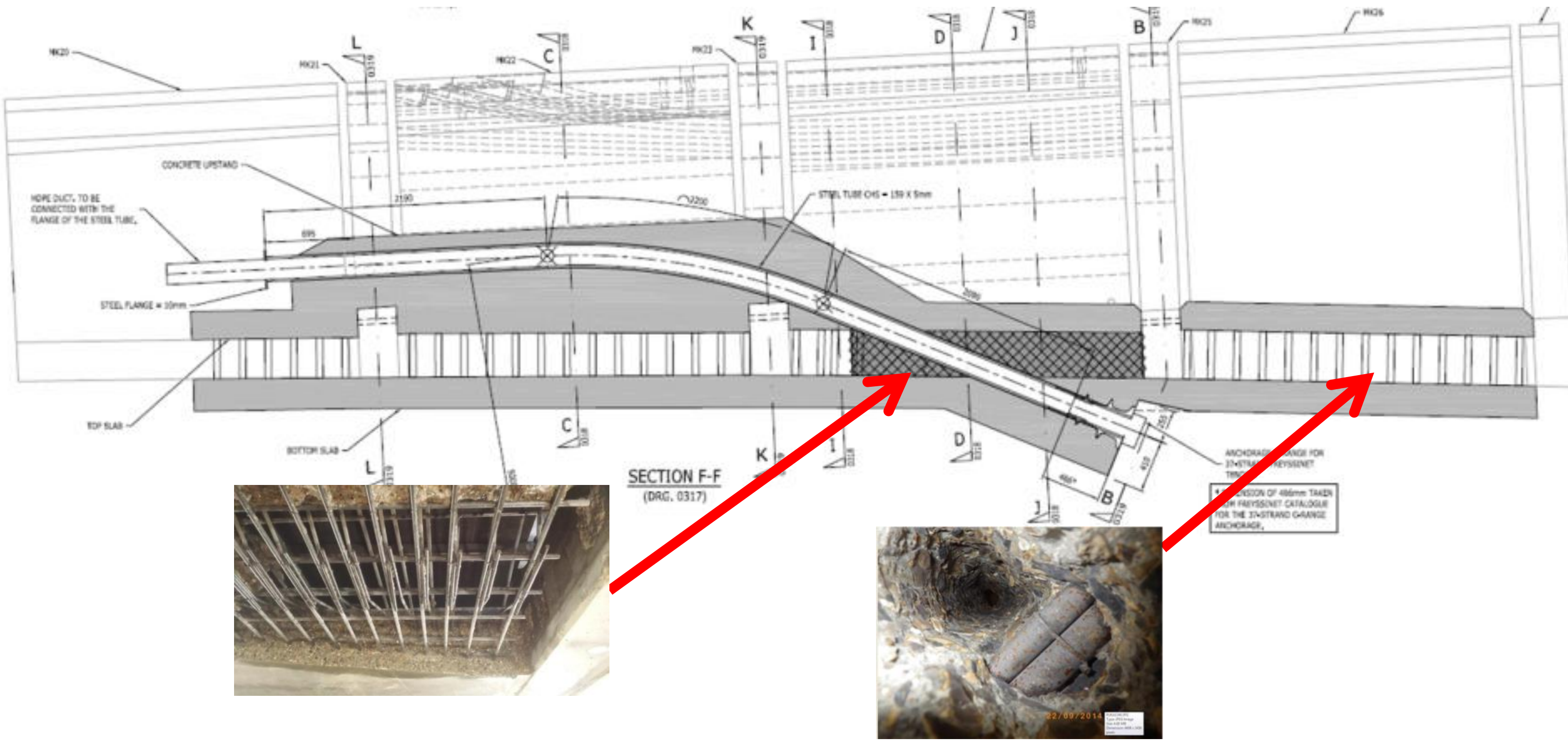
- High Tensile Steel Bars; yield stress = 1200 N/mm^2
- Maximum Diameter M52 (47mm)

Corrosion Protection

- Tubes and caps filled with petroleum wax

Prestress Replacement

Long Tendons - Anchors



Prestress Replacement

Long Tendons - Anchors

Prestress Replacement

Long Tendons - Anchors

Prestress Replacement

Long Tendons – System

- 7-Wire Strand; fpk = 279kN
- 6 x 37 Strand Deviated Tendons
- Maximum strand length 350m length

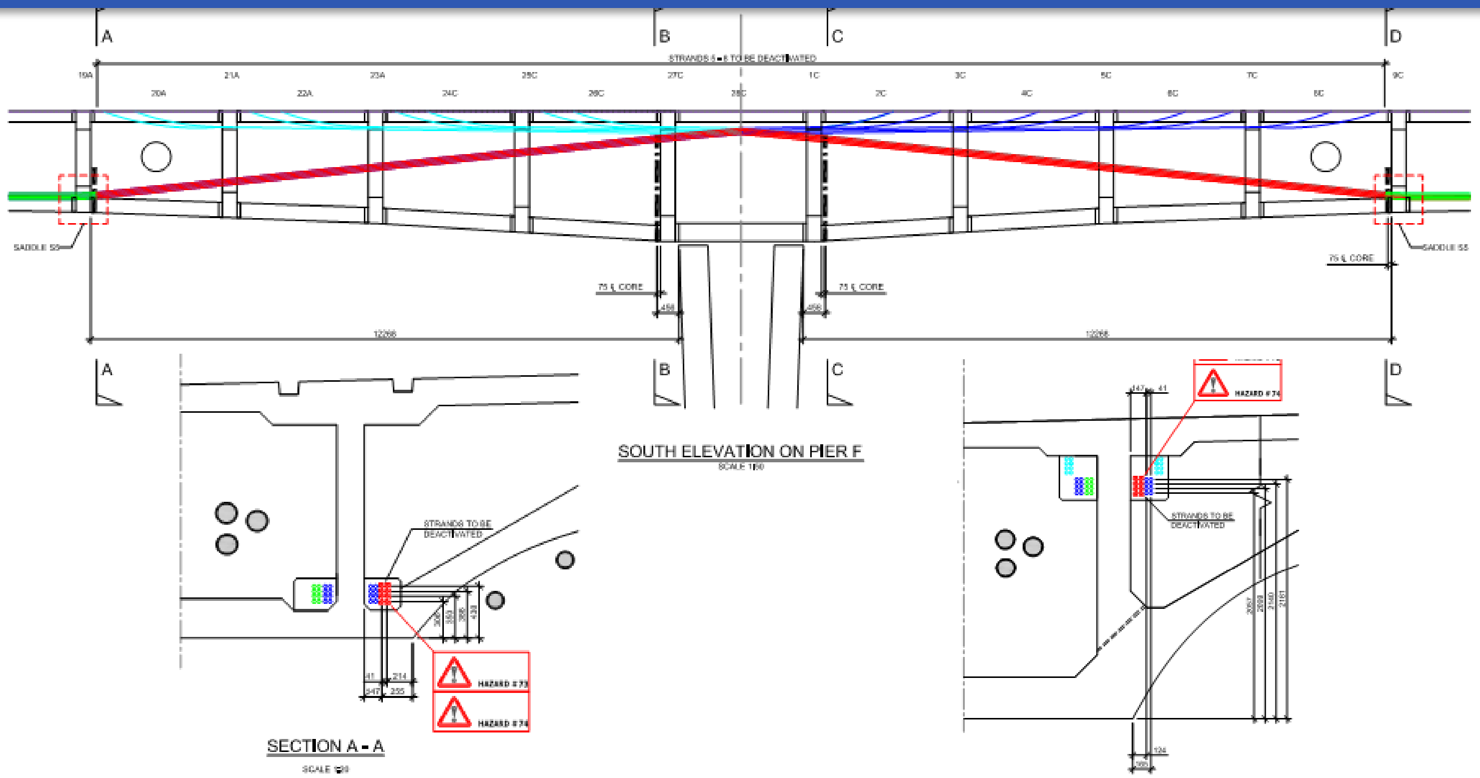
Corrosion Protection

- Wax filled HDPE Duct
- Un-sheathed galvanised strand
- Individual strands cannot be destressed and removed. Necessary compromise to design requirements.

Prestress Replacement

Existing Prestress – Deactivation

- Almost possible to replace prestress without deactivating the original.
- Philosophy of Progressive Strengthening employed. No existing prestress removed until strength replaced.



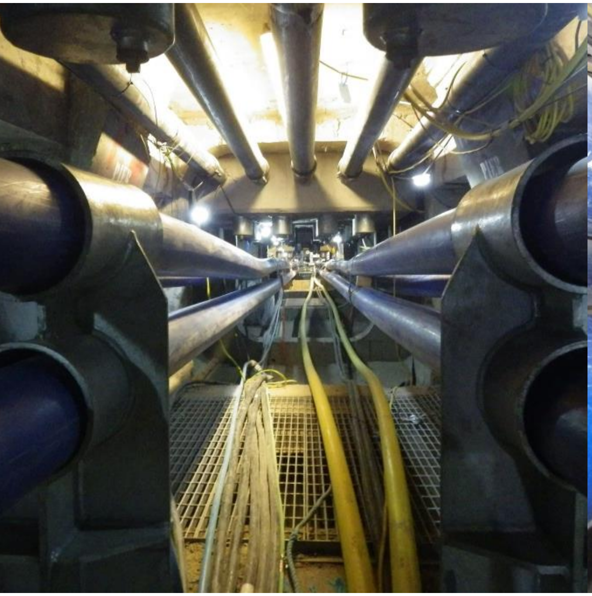
Prestress Replacement

Existing Prestress – Deactivation

- No traffic during first deactivation. Relaxed later.
- Exclusion zone plus plywood boxes to protect operatives.
- Re-anchoring was not instantaneous, the wires crept back in the concrete for several hours.

Prestress Replacement

Confined Spaces!



Acknowledgements

True Collaborative Team Effort!

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Transport for London

RAMBOLL

COSTAIN

FREYSSINET