Fire Protection of Tunnel Joints

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Motivation

- Conwy Tunnel in Wales, UK was constructed in 1986 – 1991
- The immersed tube tunnel did not have any fire protection between its joints
- This project was commissioned to rectify the deficiency

Agenda

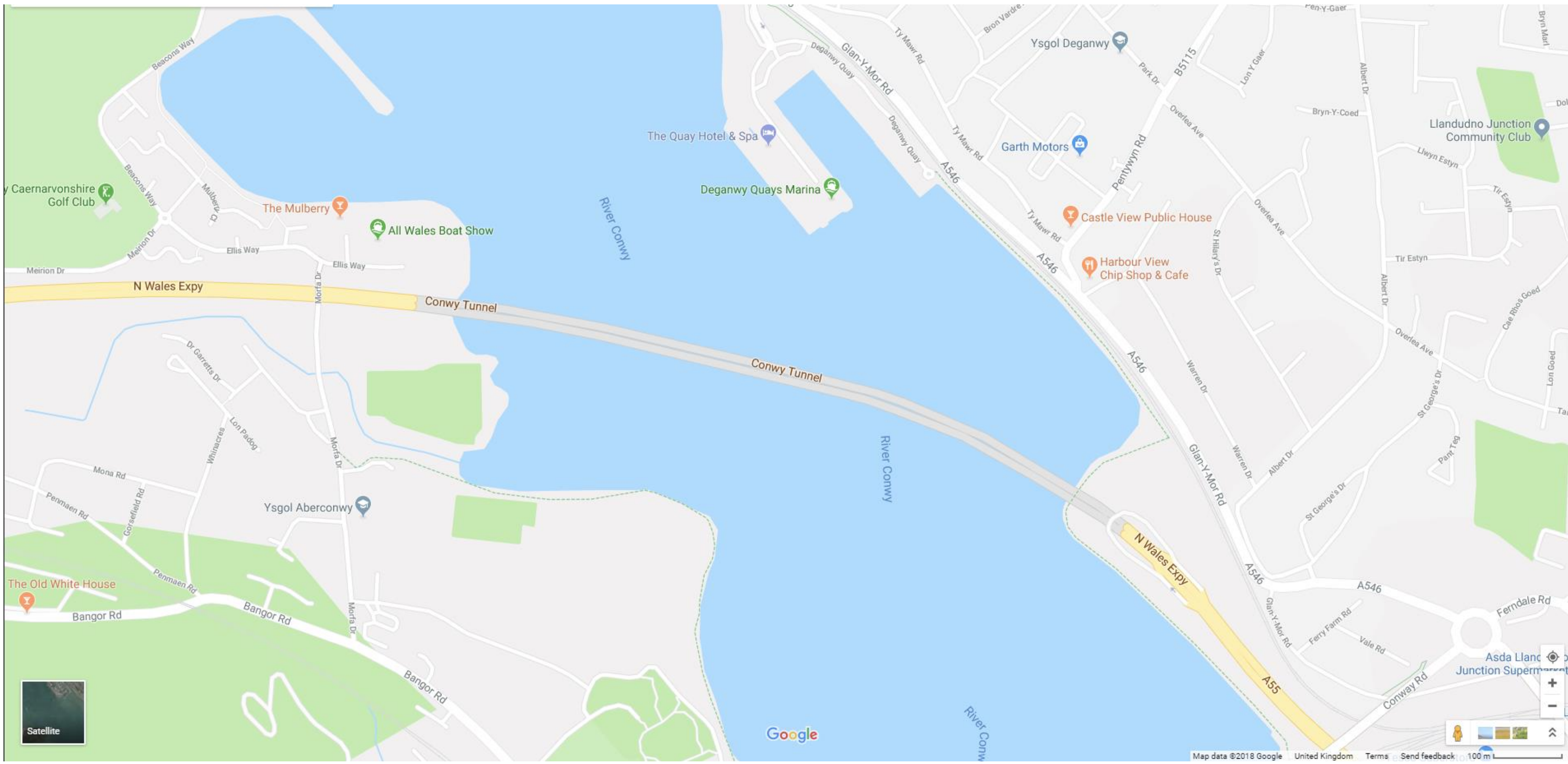
- Conwy Tunnel and its joints
- Passive fire protection criteria
- Fire protection scheme
- Fire tests
- CFD calculations
- Installation

Conwy Tunnel and its joints

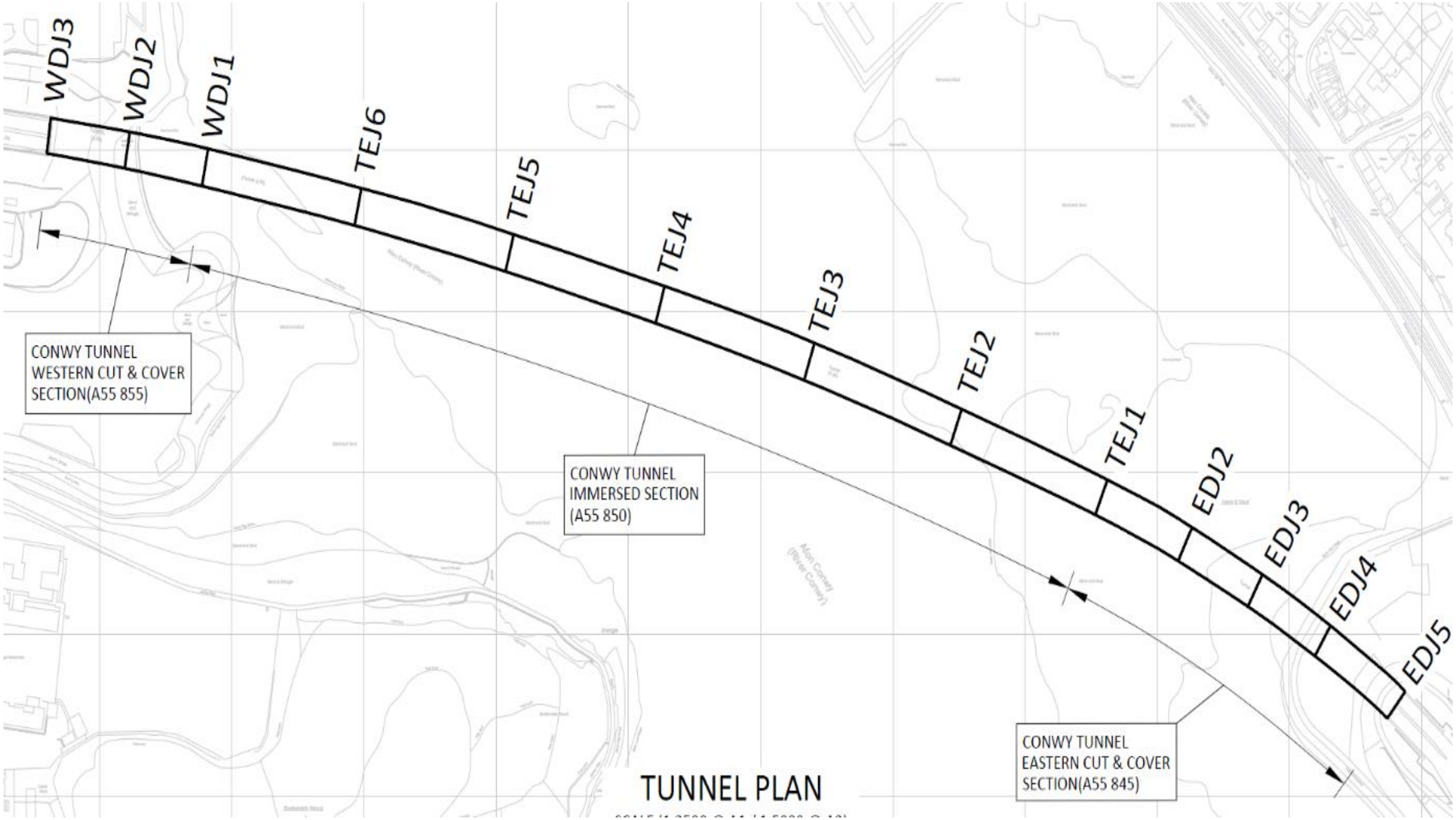
Conwy Tunnel

- Cut-and-cover portal sections:
  - East 260m
  - West 120m
- Immersed tube tunnel: 710m
- Overall length: 1090m

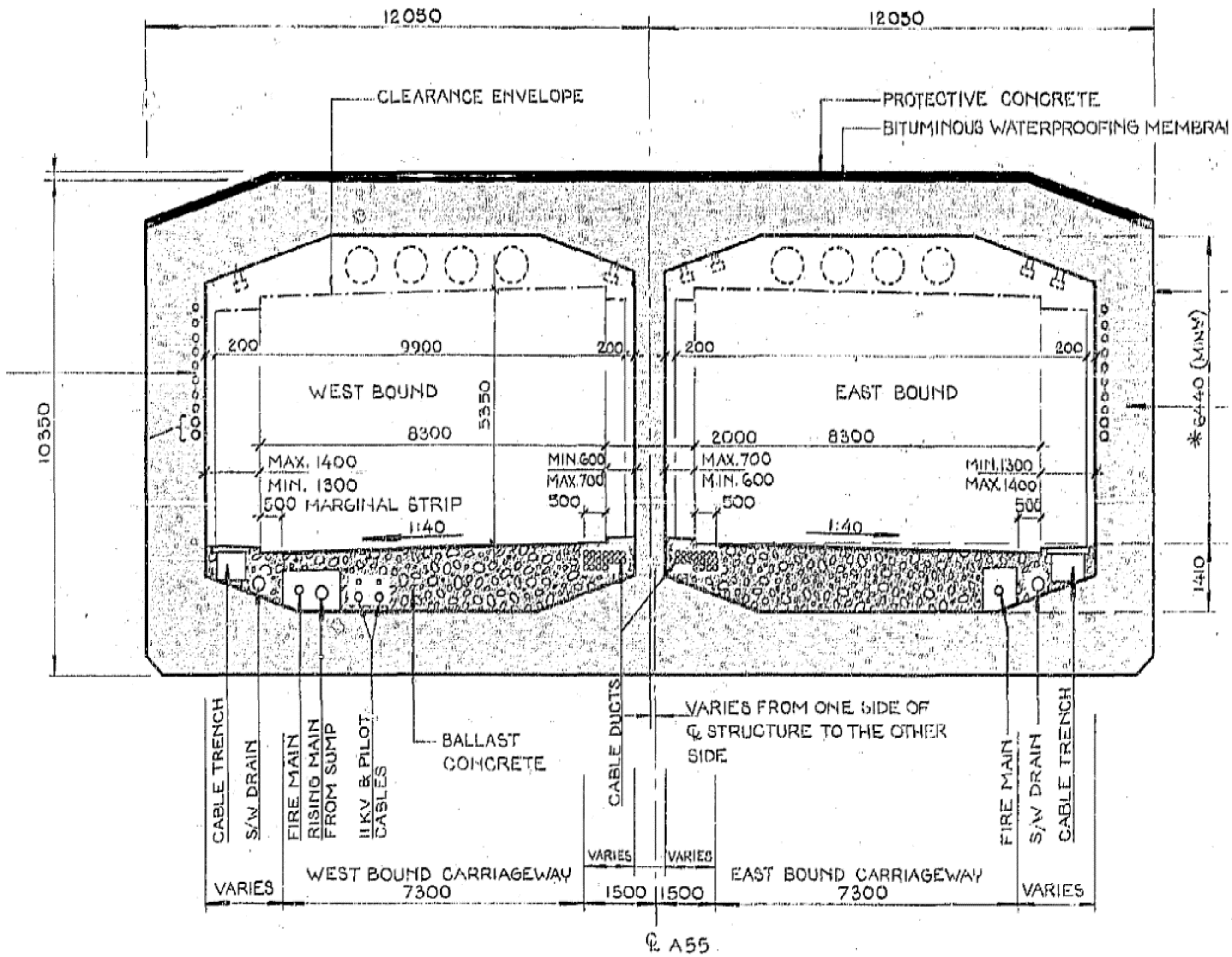
Tunnel location



Locations of tunnel joints



Typical as-built tunnel cross-section



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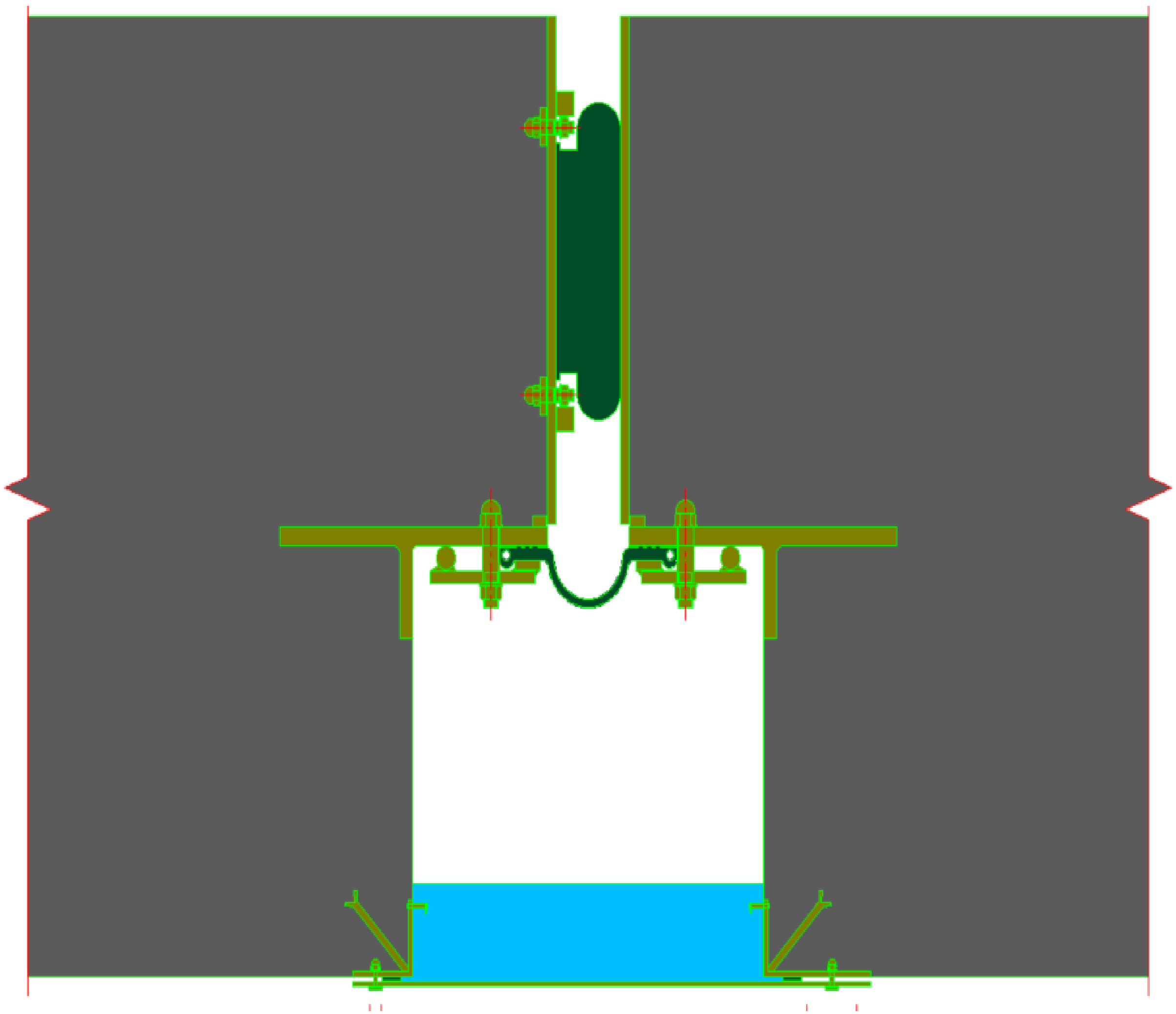
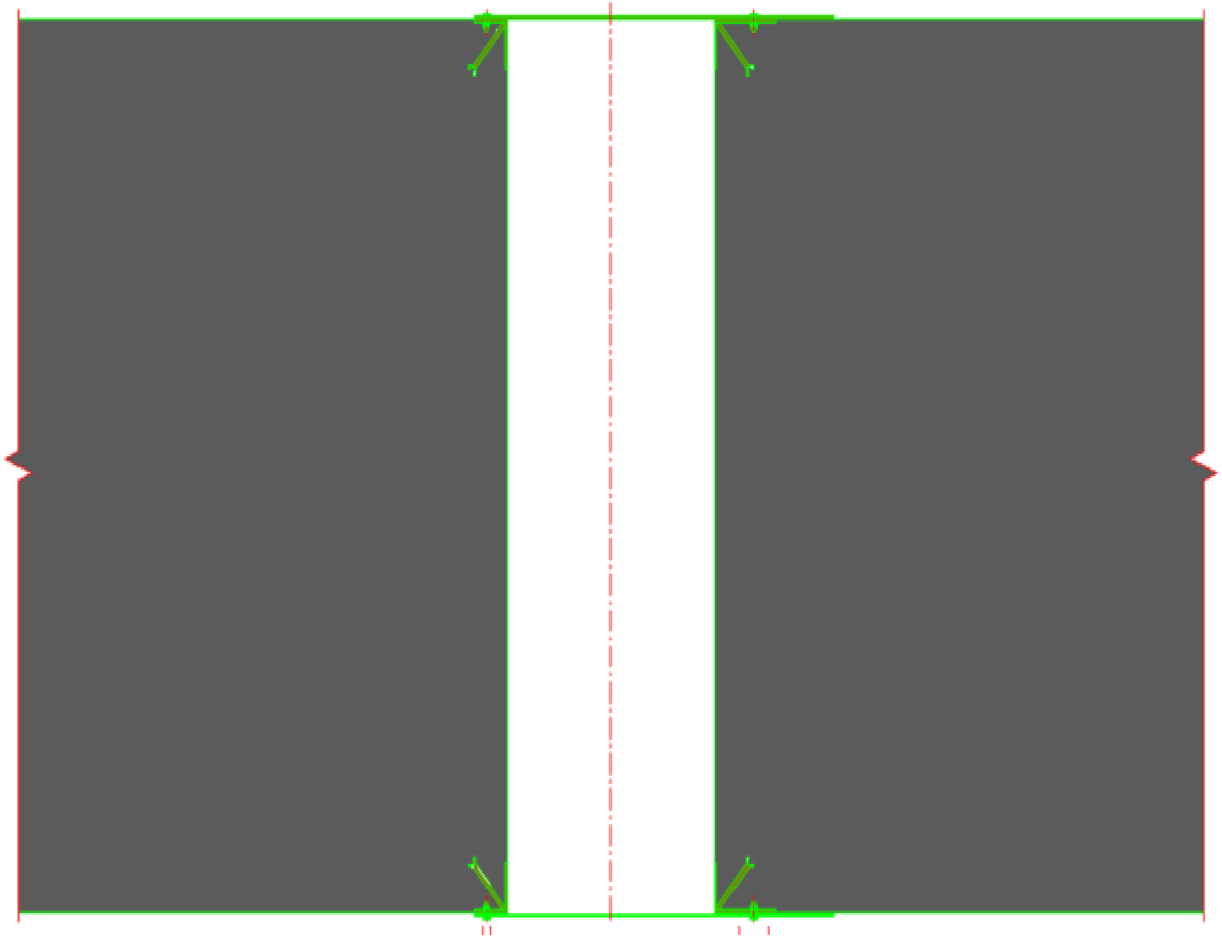
Original element soffit joint



Original element internal wall joint



Passive fire protection criteria

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Design criteria

- RWS time-temperature curve
- Up to 335mm from the joint: maximum interface temperature <350ºC after 2 hours' fire exposure + no spalling
- Average temperature of 120ºC or less at the gasket material (Omega seal)
- Fixing system should not fail during 2 hours of fire exposure

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Challenges

Challenges

- Seasonal movements of the elements with respect to each other (up to 9.5 mm)
- Significant misalignments between the element edges vertically (up to 65mm) and rotationally

Fire protection scheme

Key Design Aspects

- Passive fire protection calcium silicate fibre boards (trade name "Promatect-T")
- Bagged layers of insulation in element voids
- Paint (trade name "Ceramicoat C") to protect boards from water ingress
- Slotted holes to allow for seasonal movement
- Machined packing boards to allow for misalignments
- Composite steel/cement impact protection sheets (trade name 'Durasteel')

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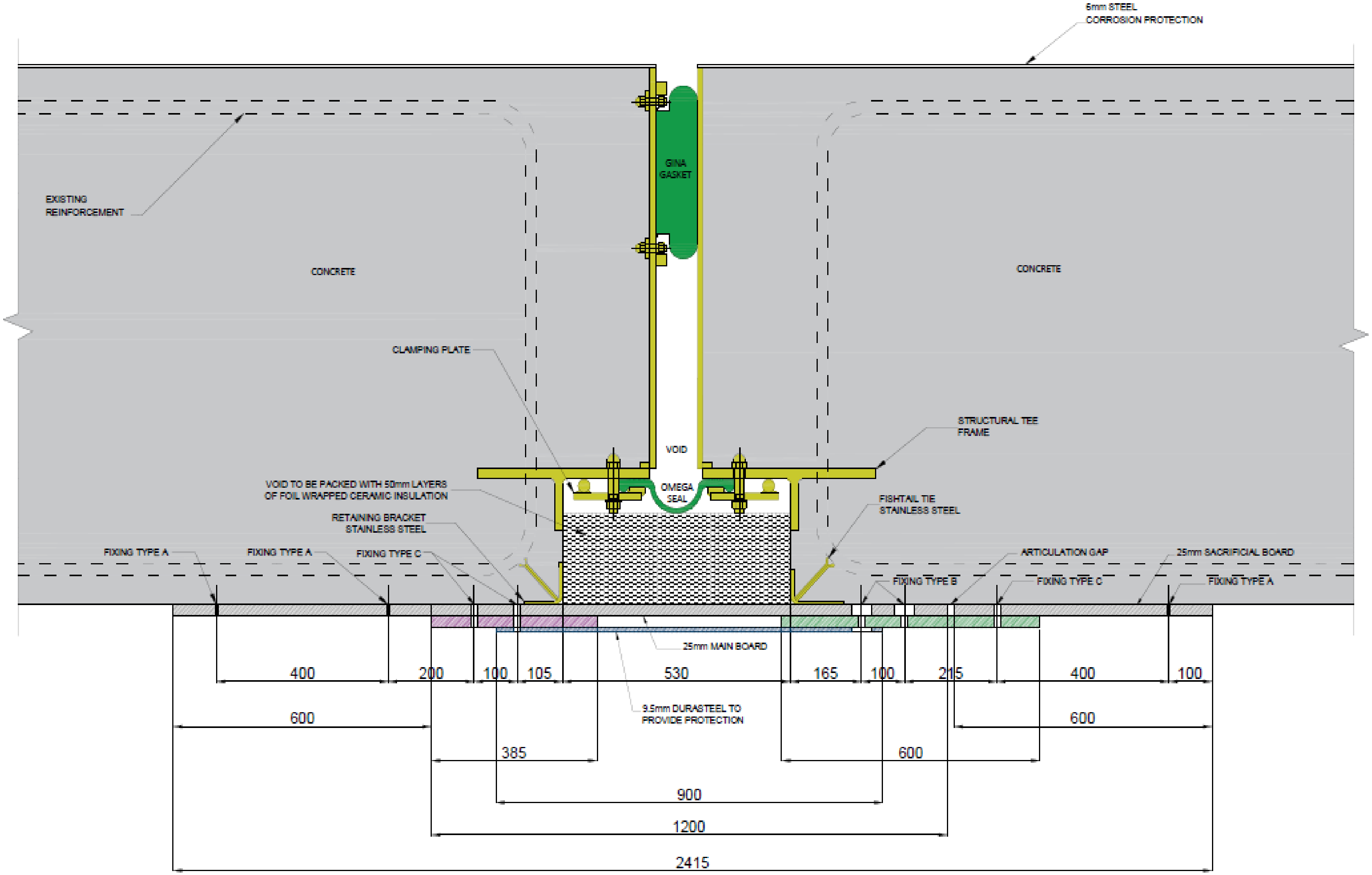

6mm STEEL
CORROSION PROTECTION
EXISTING
REINFORCEMENT
CONCRETE
GINA
GASKET
CONCRETE
CLAMPING PLATE
STRUCTURAL TEE
FRAME
VOID
VOID TO BE PACKED WITH 50mm LAYERS
OF FOIL WRAPPED CERAMIC INSULATION
OMEGA
SEAL
FISHTAIL TIE
STAINLESS STEEL
RETAINING BRACKET
STAINLESS STEEL
FIXING TYPE A
FIXING TYPE A
FIXING TYPE C
ARTICULATION GAP
25mm SACRIFICIAL BOARD
FIXING TYPE B
FIXING TYPE C
FIXING TYPE A
25mm MAIN BOARD
400
200
100
105
530
165
100
215
400
100
600
9.5mm DURASTEEL TO
PROVIDE PROTECTION
600
385
600
900
1200
2415

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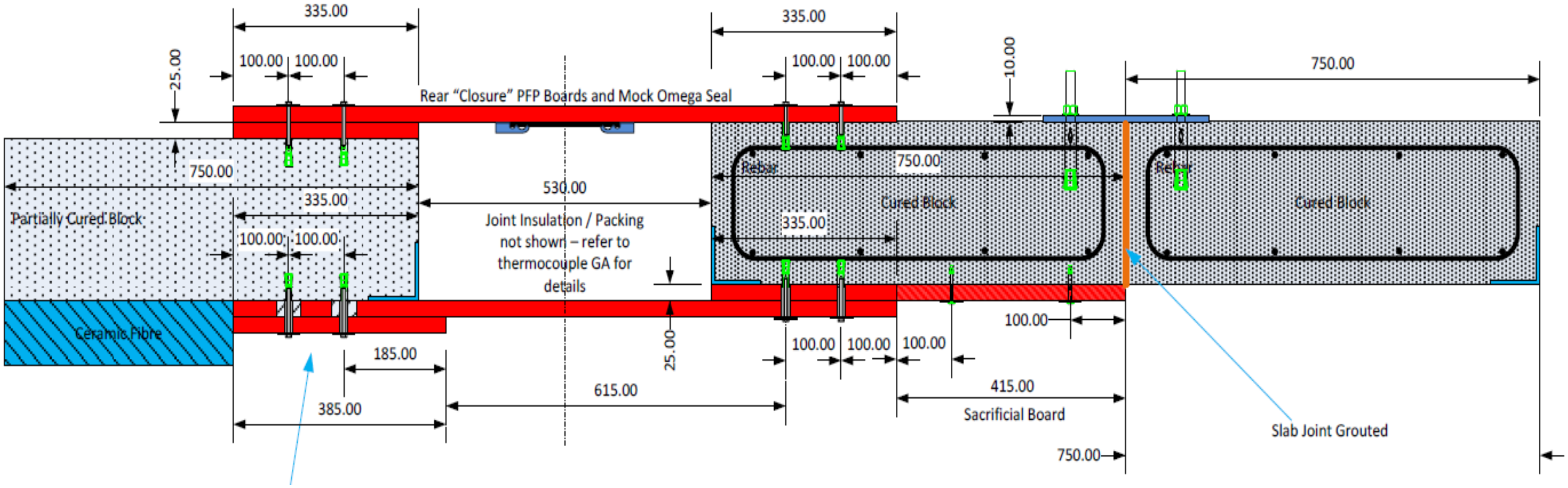
Fire tests

Fire tests undertaken

CSTB, France:

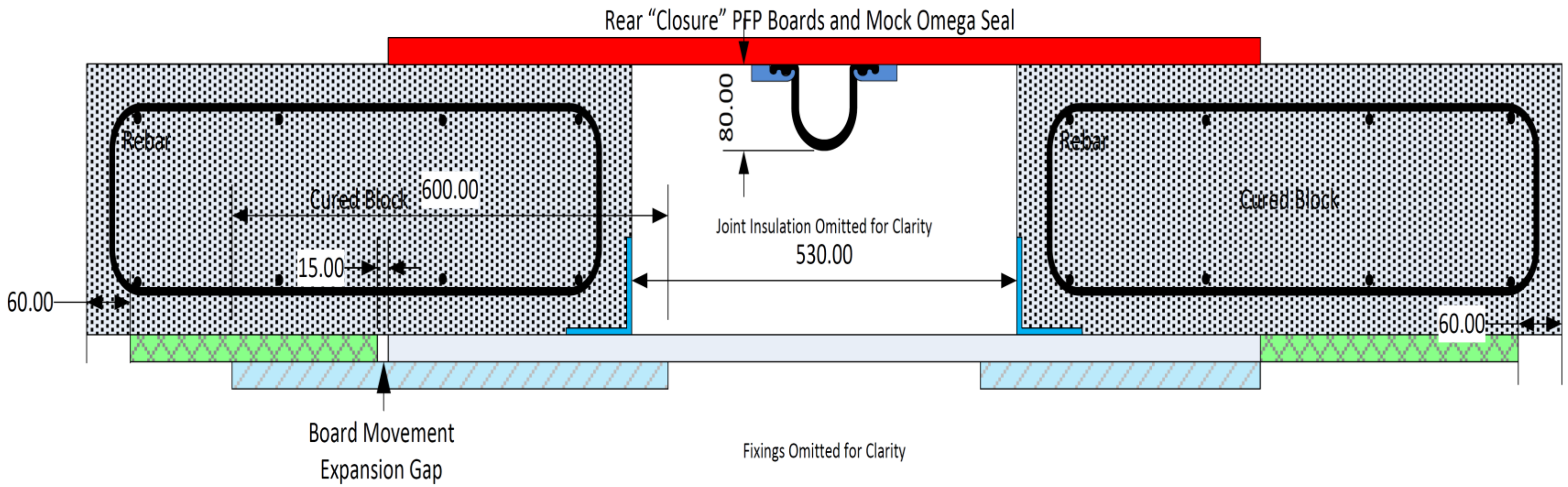
- Vertical (wall) element joint
- Horizontal (soffit) element joint
- Vertical (wall) dilation joint

Vertical (wall) element joint - 1



Vertical (wall) element joint - 2

Horizontal (soffit) element joint - 1



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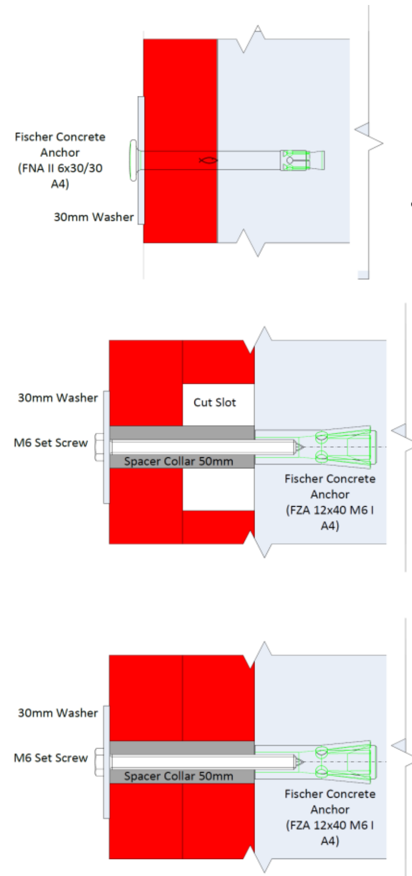
Horizontal (soffit) element joint - 2

Fixing Detail (NTS)

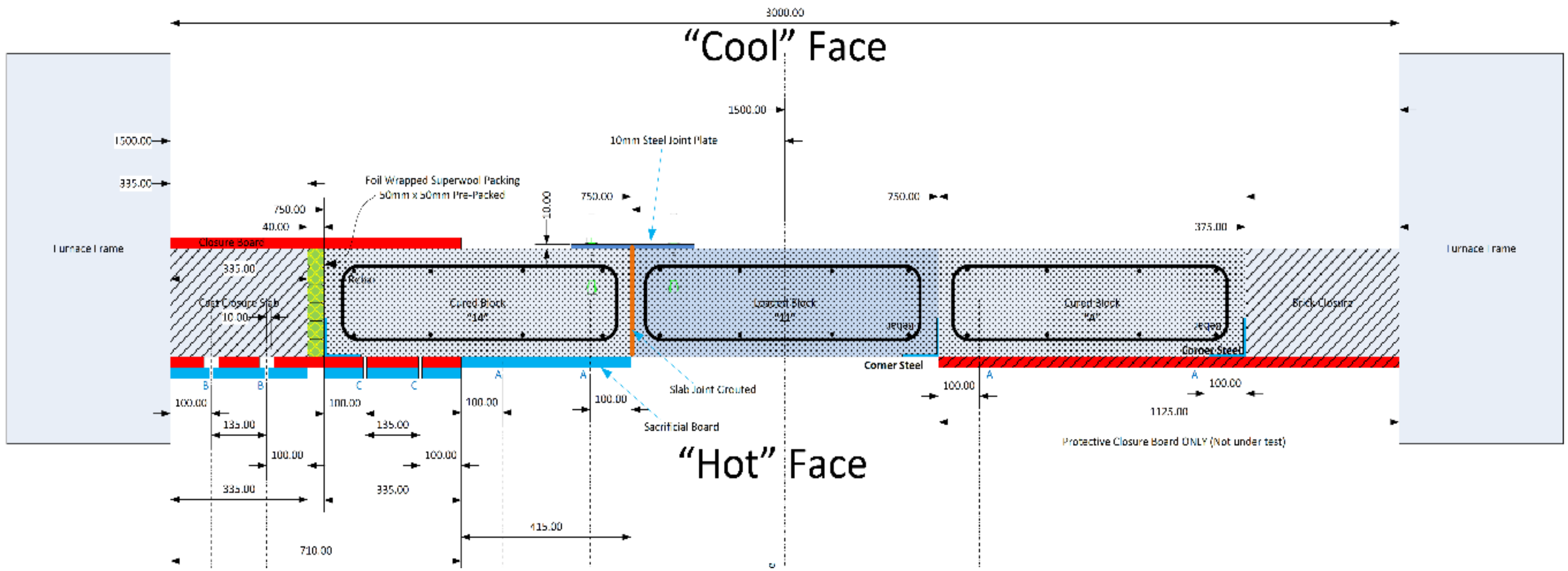


Type "A"

Type "B"

Type "C"

Vertical (wall) dilation joint - 1



Vertical (wall) dilation joint - 2

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Compressive Stress

- Load of 1750kN applied centrally to the slab provided a uniform compressive stress of $9.3N/mm^2$ across the section
- The load was displaced to give an eccentricity of 14mm, which gave a combined (axial + bending) compressive stress of $12.5N/mm^2$ on the front face of the unprotected test slabs

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Measured Results

- The three fire tests confirmed that all the passive fire protection criteria had been satisfied

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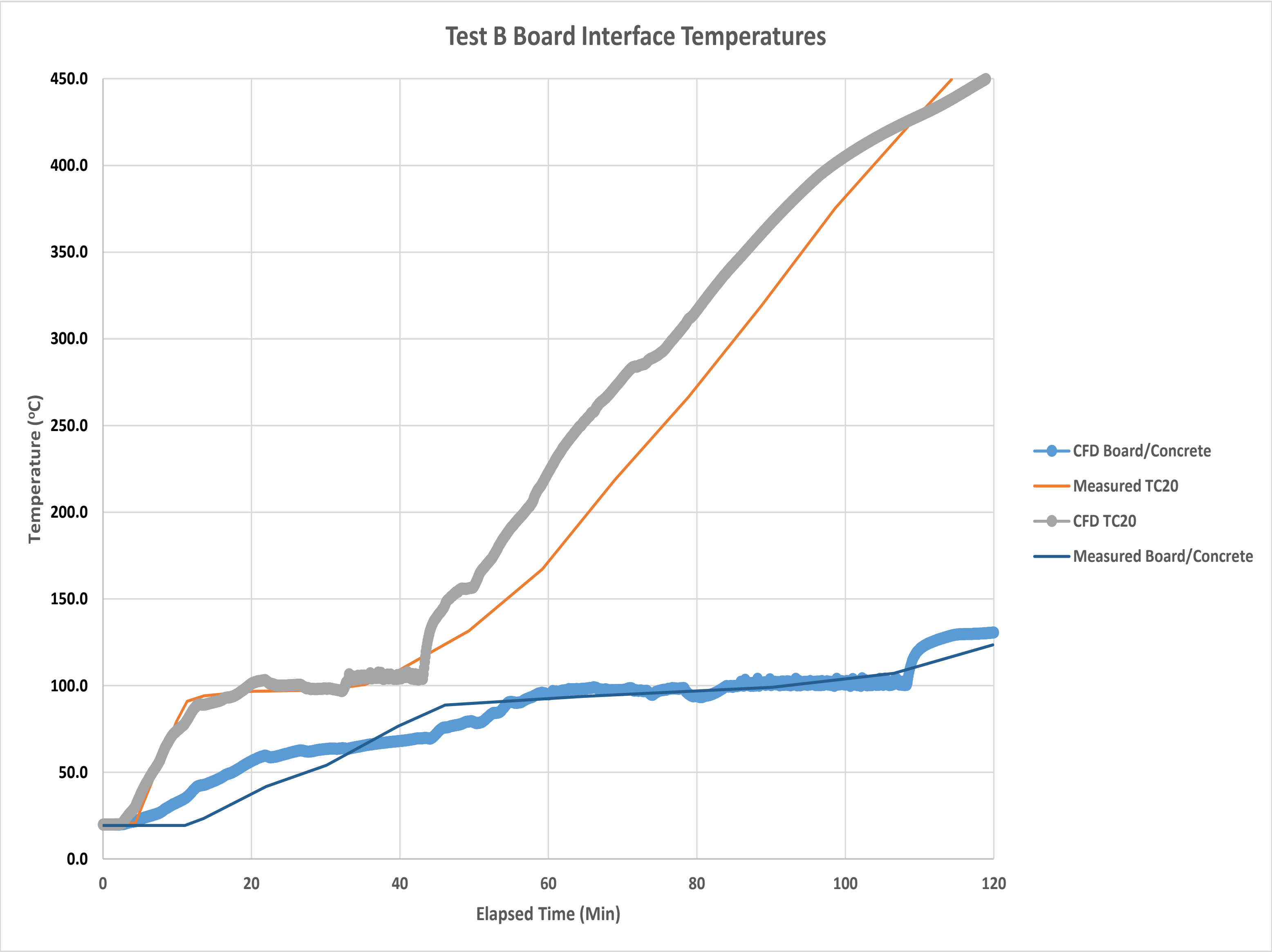
CFD calculations

Purpose of CFD calculations

- To verify the CFD calculations by comparison to experimental results
- To account for the various types of joints and their particular layouts

Movement of Liquid Water and Vapour

- Calculated through the passive fire protection board & concrete
- Essential for obtaining good predictions with experimental results



Test B Board Interface Temperatures
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Temperature (°C)
0
20
40
60
80
100
120
Elapsed Time (Min)
CFD Board/Concrete
Measured TC20
CFD TC20
Measured Board/Concrete

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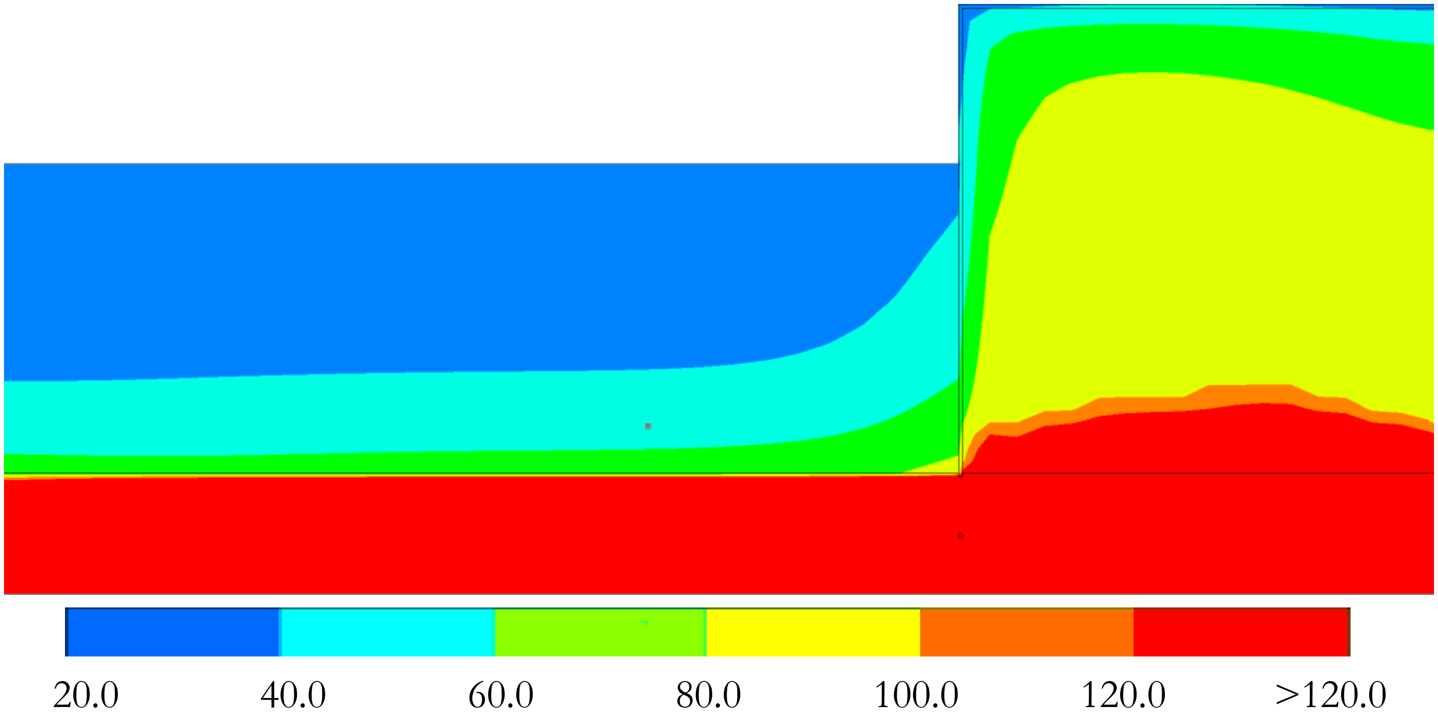
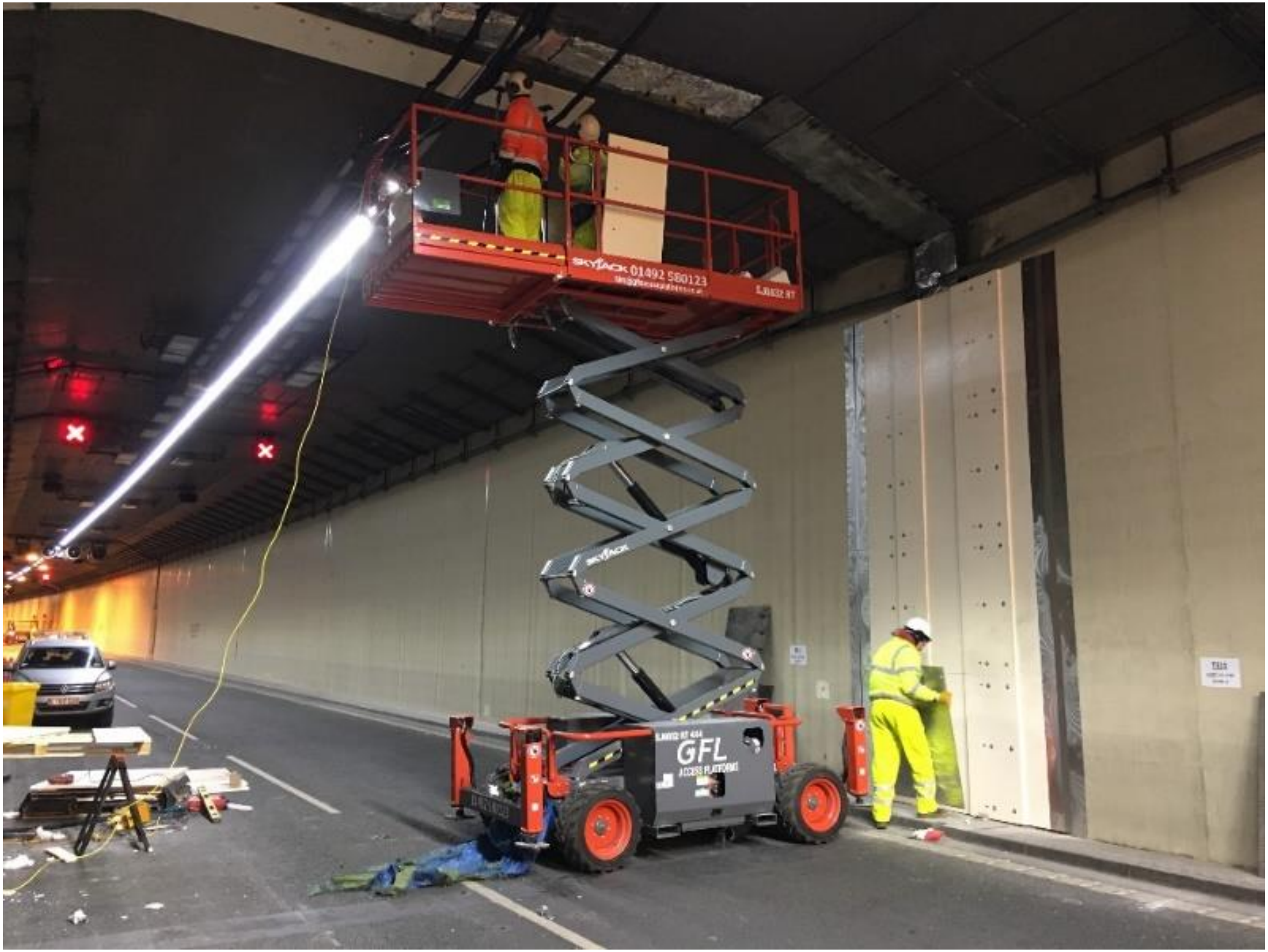
Test 2 Predicted Temperature through Test Sample at 2 hours



Installation


SKYJACK 01492 580123
GFL
ACCESS PLATFORMS
SKYJACK

Review

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- CFD calculations
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