



HIGH SPEED 2 (HS2) CHILTERN TUNNEL PORTALS and SHAFTS

VYSOKORYCHLOSTNÍ TRAŤ HS2 CHILTERN TUNNEL PORTÁLY a ŠACHTY



Konference *ŽELEZNIČNÍ MOSTY A TUNELY*

22/01/2026

RENDEL

- An international consultancy firm providing engineering design and related services to clients involved in major engineering and construction projects worldwide
- A proud history spanning over 185 years and experience in all continents
- Extensive expertise in major infrastructure projects in the rail and road sectors, including tunnels, bridges, highways, geotechnics, energy, industry, ports and maritime sectors
- 70% turnover on design and build (D&B) contracts, 30% turnover from IFI's funded schemes and expert services
- Winners of Queen's Awards (three times)
- Over 200 first of a kind and global megaprojects



OUR HISTORY

- 1838** James Meadows Rendel, the 6th President of the Institution of Civil Engineers (ICE) 1851-1853 formed Rendel & Partners in London, UK. The company later changed its name to Rendel, Palmer & Tritton
- 1985** Following the merger of High-Point, a specialist commercial claims consultancy established in 1970 and Rendel, Palmer & Tritton, one of Britain's most respected consulting engineering firms Headquartered in London, UK, High-Point Rendel was formed
- 2013** High-Point Rendel celebrated the 175th anniversary of its origins in London
- 2015** Rendel separated from High-Point and became a wholly owned subsidiary of Ingérop, a large multi-disciplinary French engineering company with more than 3000 employees worldwide at the time. Rendel retained its fully British registered company status and continued to do business in the geographical areas and market sectors in which High-Point Rendel was previously operating
- 2018** Rendel opened a new office in Australia, Rendel Ingérop Pty Ltd, increasing its global reach
- 2019** Rendel extended its UK presence with the opening of an office in Birmingham
- 2022** Rendel opened a third UK office in Bristol. Rendel acquired Aspec Engineering in Australia, gaining four additional offices in Australia
- 2023** Rendel celebrated the 185th anniversary of its origins in London and acquired T+RS Engineering in Doncaster, UK
- 2024** Rendel opened new offices in Dublin, Ireland
- 2025** Rendel celebrating 10th anniversary as part of the Ingérop Group



INGEROP GROUP

Ingérop is a leading French and international engineering consultancy

Independent of any outside shareholder group, Ingérop is directly owned by its management and by the company's mutual investment fund

3500

employees

HUMAN RESOURCES

458

million Euros

THE CONSOLIDATED
TURNOVER

100

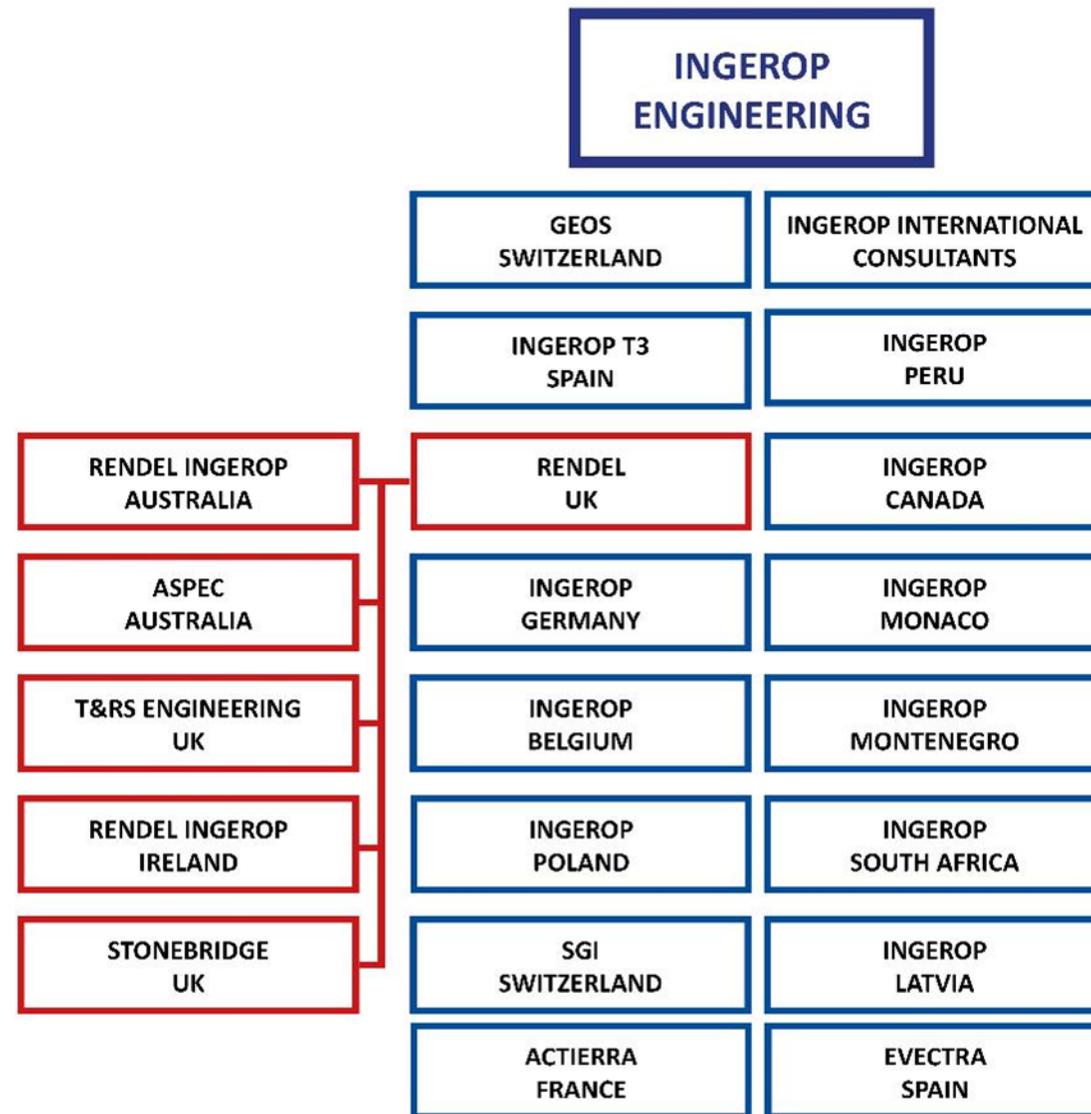
offices

WORLDWIDE

70

countries

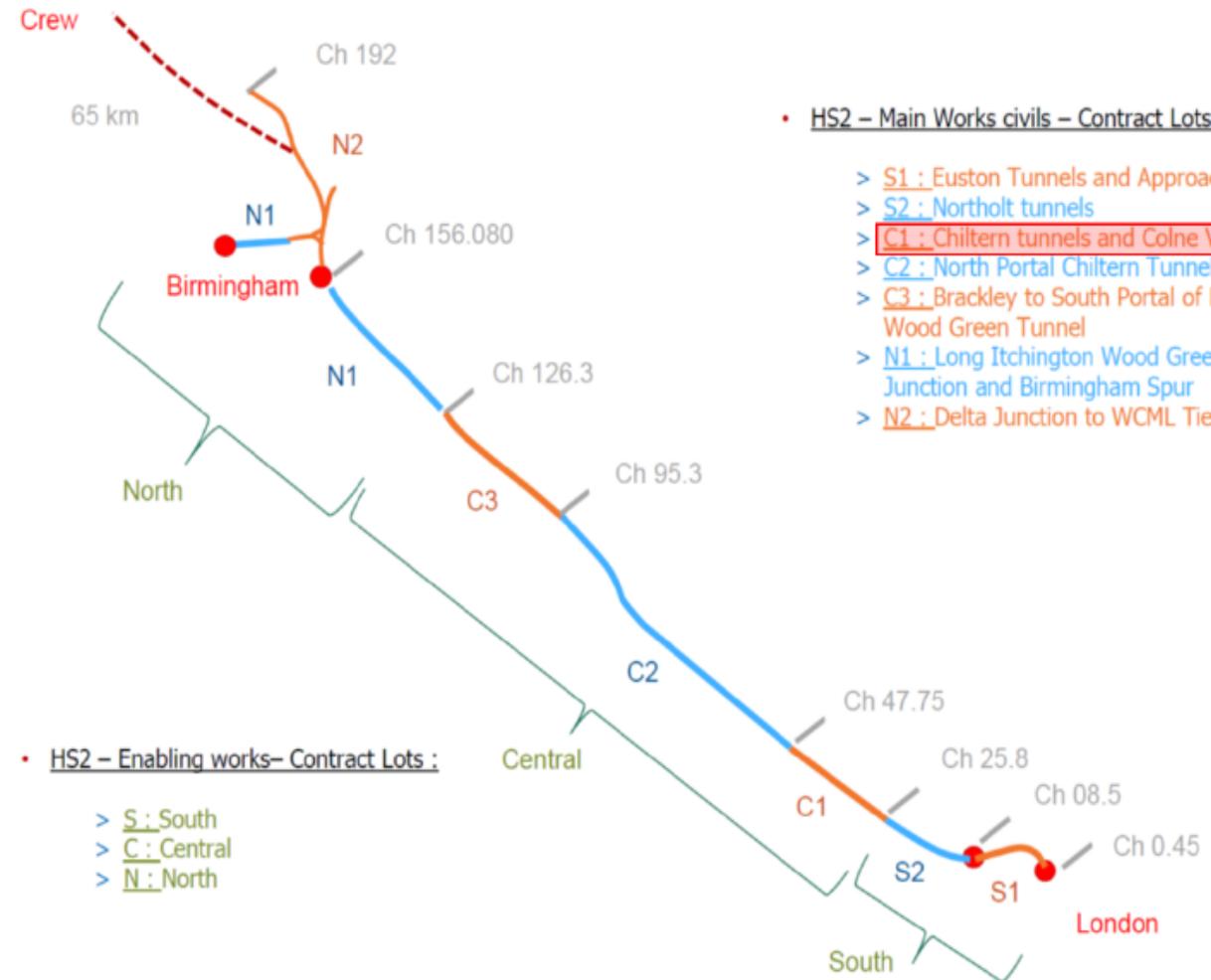
INTERNATIONAL
ACTIVITY





HS2 PROJECT DETAILS

OVERVIEW – CENTRAL 1 (C1) PORTION OF HS2



HS2 MCWC C1 ALIGN JV & ALIGN- D



Department
for Transport

HS2

AL||GN



VolkerFitzpatrick

**Sir Robert
McALPINE**

AL||GN-D

AL||GN

Jacobs

INGEROP
Inventing for tomorrow

Rendel
est. 1838



The C1 Contract

Central 1 (C1)

C1 consists of 21.6km of high speed rail infrastructure :

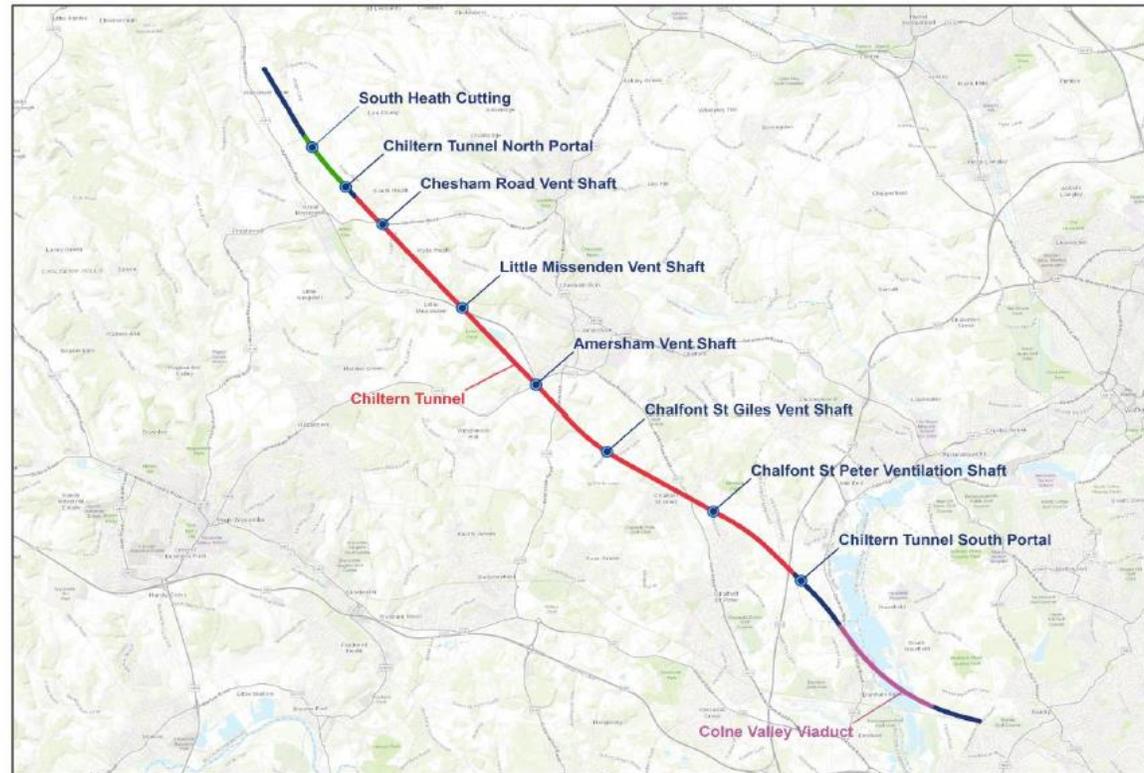
- 3.37km viaduct
- 16.04km twin-bored tunnel
- 5 shafts handling both intervention and tunnel ventilation
- The Align South Portal main site is located to the west of London just inside the M25
- Align JV are also delivering the South Heath Cutting in the Central 2 section

At peak production:

600+ C1 Align IPT personnel

2,500+ people on site

120+ registered contractors



The C1 Contract – Tunnel: Shafts and Portals Details

Chiltern Tunnels

- 16.04km twin-bore tunnels through the Chiltern Hills
- 1 TBMs, Florence and Cecilia, built to handle chalk with flint bands
- 170m long and 2,200t each
- Excavation diameter – 10.26m
- Concrete segments 2 x 0.4m
- 7 segments per ring – 112,300 segments in total
- 3 million m³ excavated material produced 24/7 and processed through the slurry treatment plant at the South Portal
- 5 ventilation and access shafts

Shafts

- 5 ventilation and access shafts
 - Approx. every 3km along the tunnels
 - Hosting tunnel ventilation fans in a basement for the first four shafts
 - Key data:
 - 35 – 65m deep
 - 18m internal diameter
 - Diaphragm walls 1.2m thick and up to 80m deep
 - Head houses designed to blend into the natural environment, an Area of Outstanding Natural Beauty (AONB)

South Portal

- Approx. 20m high headwall at angle of 70 degrees
- Shotcrete Facing
- 634 Soil nails installed
- Combination of steel and GFRP nails and reinforcement in tunnel eye

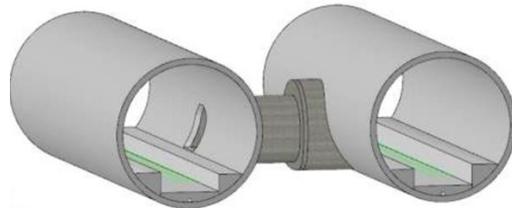
North Portal

- 18m high multilevel propped diaphragm wall headwall
- Combination of steel and GFRP reinforcement in tunnel eye

Contract C1 Scope



North Portal



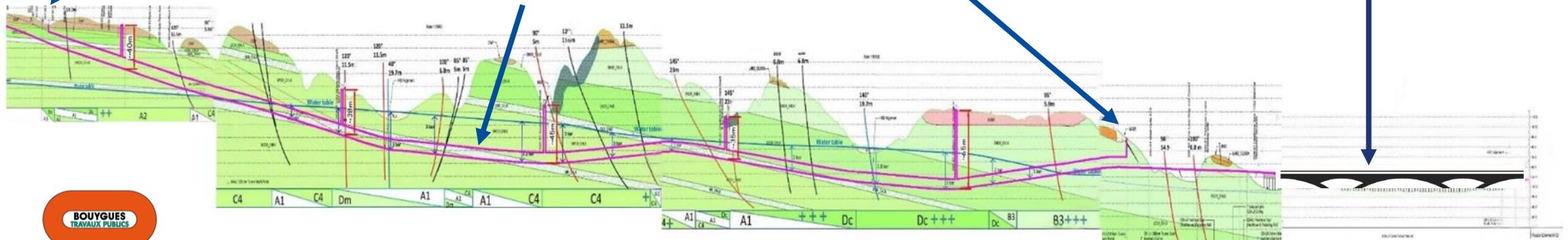
16.06km Twin Bored Tunnel with 5 shafts and 43 cross passages



South Portal



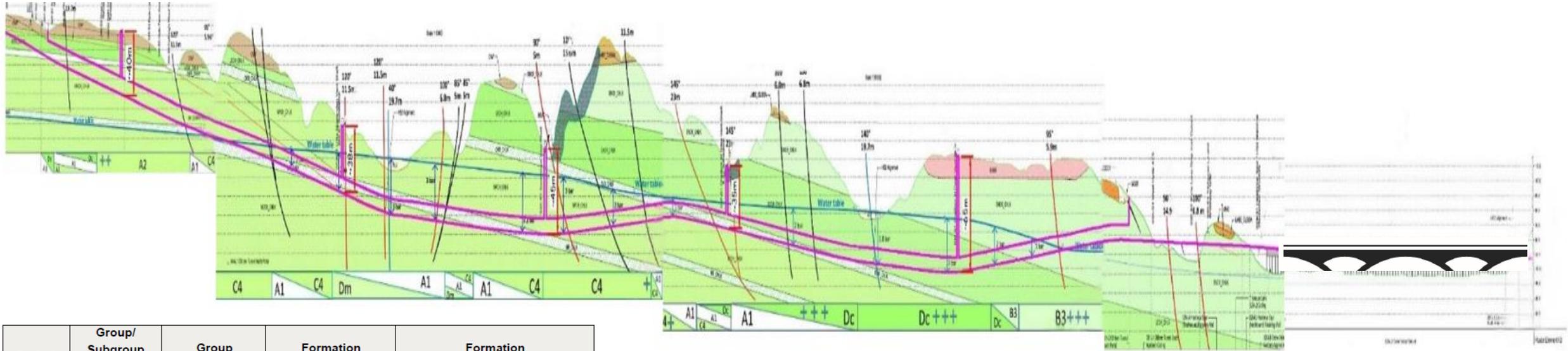
3.4km Colne Valley Viaduct



BUILDING FOR LIFE



Contract C1 – Route Wide Geology (Ground Conditions)



Period	Group/ Subgroup (Current Name)	Group (Former Name)	Formation (Current Name)	Formation (Former Name)
Palaeogene	Lambeth Group	Woolwich and Reading Beds	Reading Formation	Reading Beds
Cretaceous	White Chalk Subgroup	Middle and Upper Chalk Undivided / Sussex White Chalk Formation (Part)	Newhaven Chalk Formation	Newhaven Chalk Member / Blandford Chalk Member
			Seaford Chalk Formation	Seaford Chalk Member / Blandford Chalk Member
			Lewes Nodular Formation	Akers Steps and St Margarets Members / Lewes Nodular and Flinty Chalk Member / Lewes Nodular Chalk Member
			New Pit Chalk Formation	Aycliff Member / Shakespear Cliff Member / Upper Holywell Beds and New Pit Beds / New Pit Chalk Member
			Holywell Nodular Formation	Holywell Chalk Member / Lower and Middle Holywell Beds

Epoch	Strata
Holocene	Made Ground
	Alluvium
Pleistocene	River Terrace Deposits
	Valley Gravels
	Head
	Glacial Till
	Glaciofluvial Sands and Gravels
	Clay-with-flints



NORTH & SOUTH PORTALS

North and South Portals

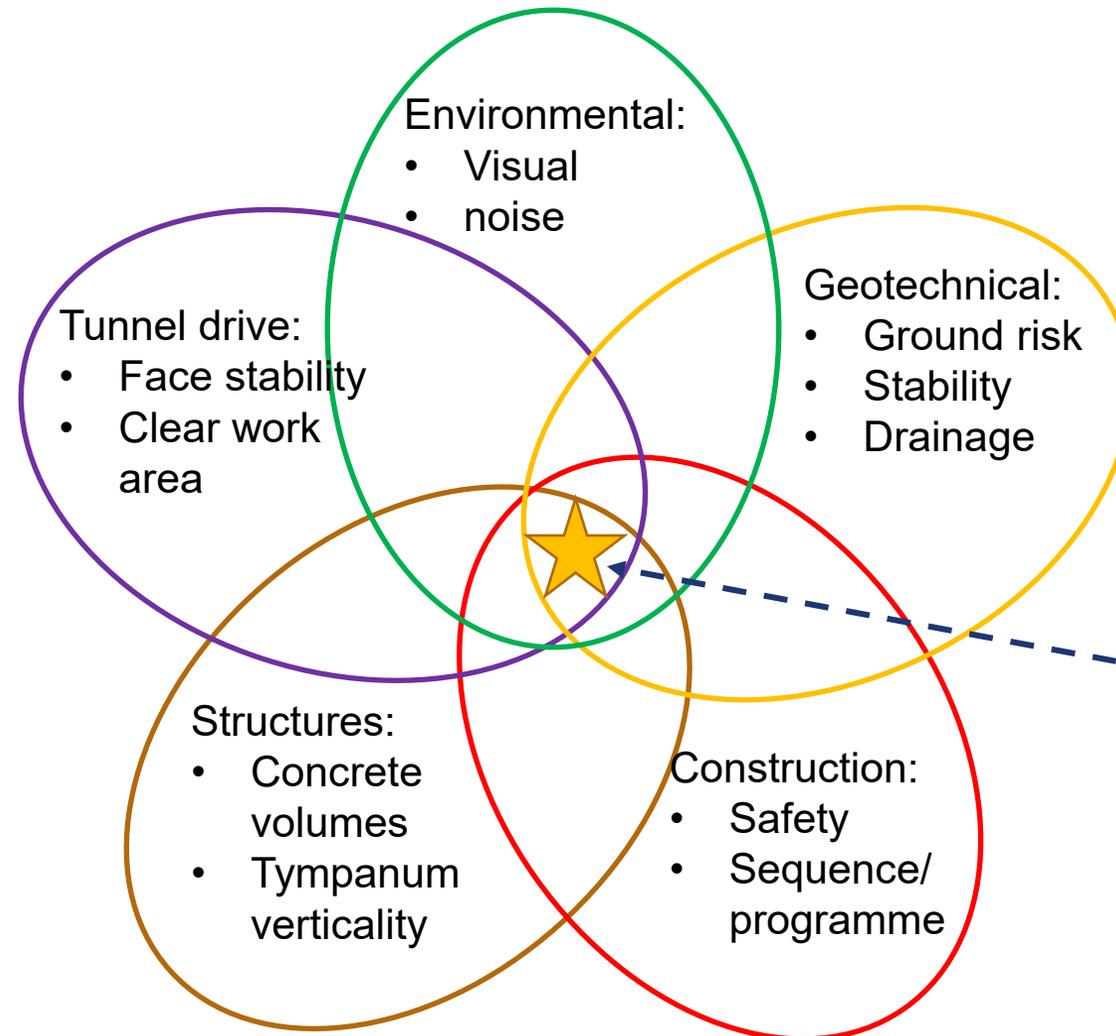


South Portal Headwall



North Portal Headwall

Portal Design - Collaborative Design



The right solution is one that addresses the requirements of all those involved & delivers good value for money

Portal Design - Design Development

Secant Piled Wall (Anchored)

Pros

- Robust structure to overcome limited ground information

Cons

- Stability above tunnel crown at break-in
- Piles would need to be anchored deep in the chalk (turbidity)

Scheme Design

Soil Replacement with CTB above tunnel Crown + Soil nailing

Pros

- Stiffness provided by the reinforced earth and CTB can be specified

Cons

- Large excavation required – constraint on the construction cost and programme
- Global stability of headwall cannot be maintained if $c' < 100$ kPa for CTB, i.e. construction quality control dependent

Value Engineering

Full Height Soil Nailing

Pros

- No additional excavation required – construction cost and programme
- Soil nails to stiffen the ground, thus, canopy tubes not required
- Simpler tympanum connection

Cons

- Facing design is more complex

Detailed Design

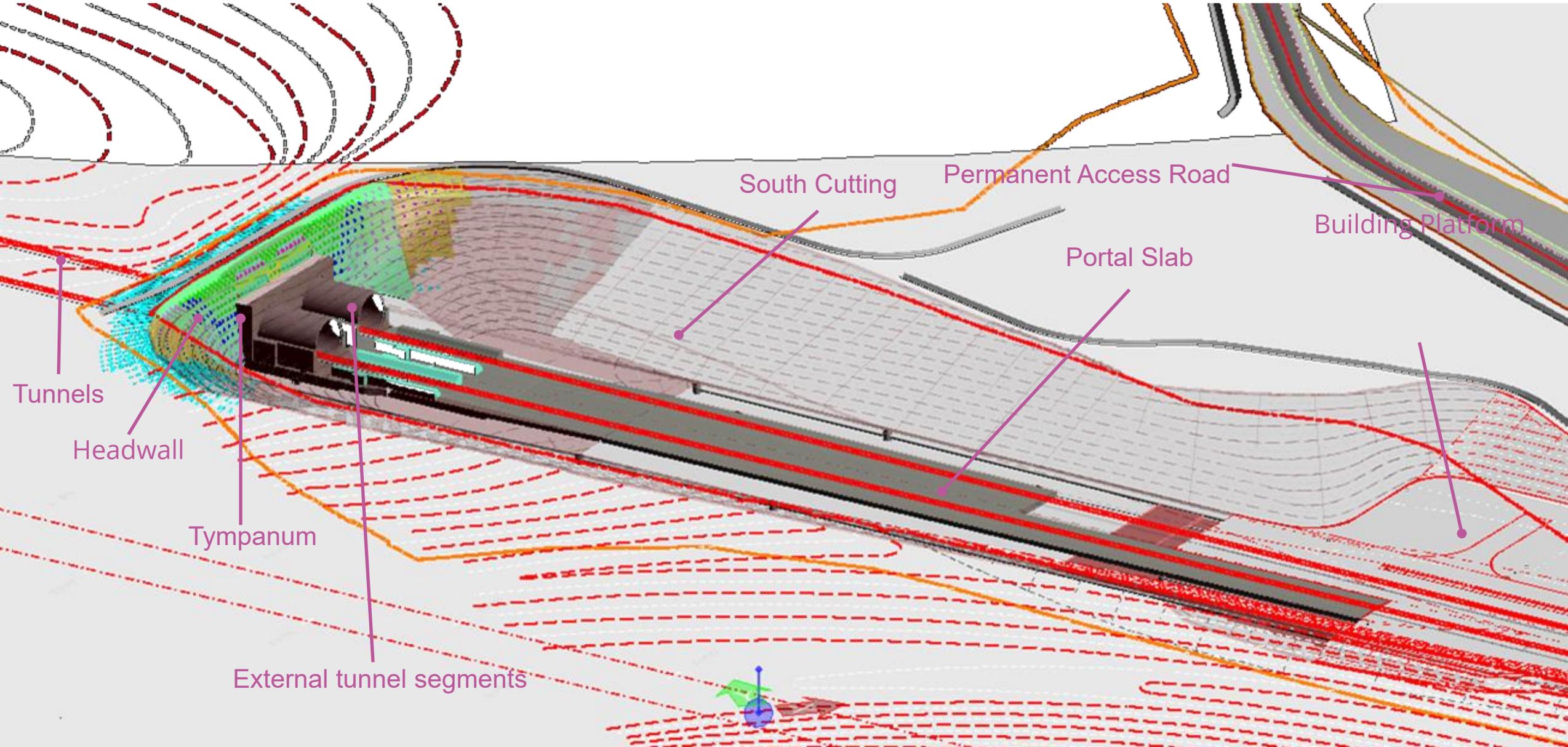
Soil Nailed Headwall – Design Approach

Codes/Standards:

- HS2 Technical Standard
 - Tunnel Portals
 - Earthworks
- BS8006:2:2011
 - CoP Part 2: Soil Nail Design
- BS EN 1997-1:2004
 - Geotechnical design
- BS EN 14490:2010
 - Exec. of Special Geotechnical Works
 - Soil Nailing

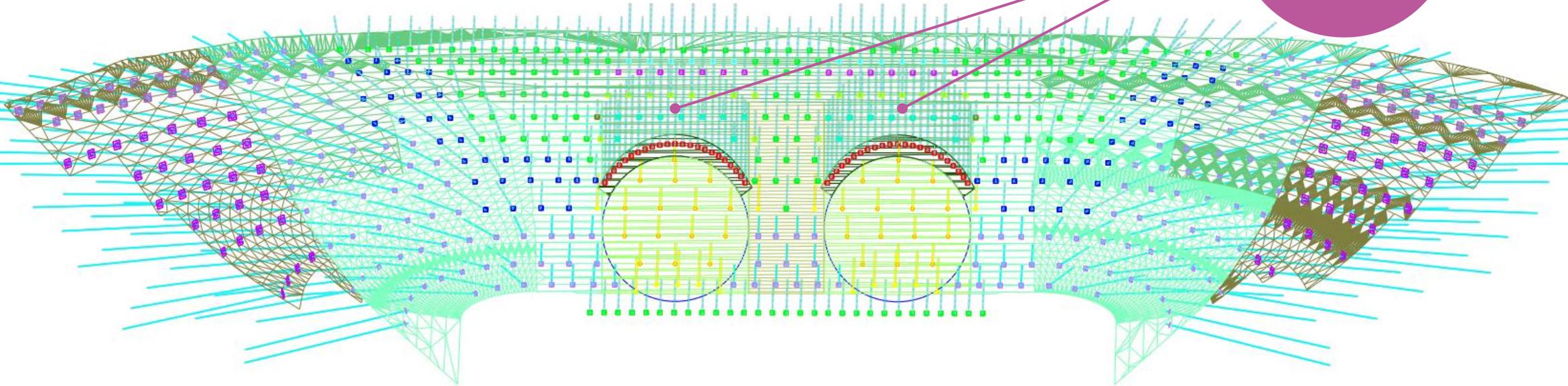


South Portal – Tympanum & Slab

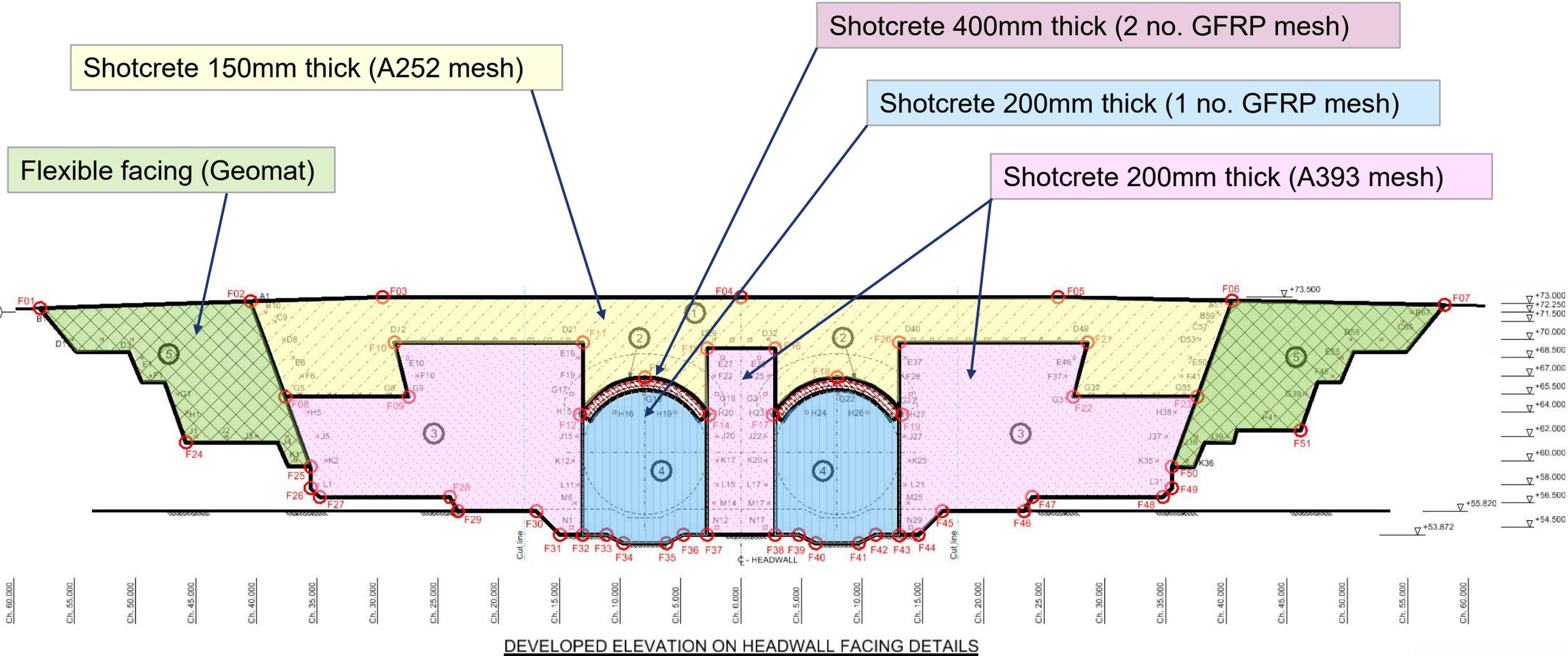


Chiltern Tunnel Soil Nailed Headwall

Optimization of soil nail arrangements above tunnel crown

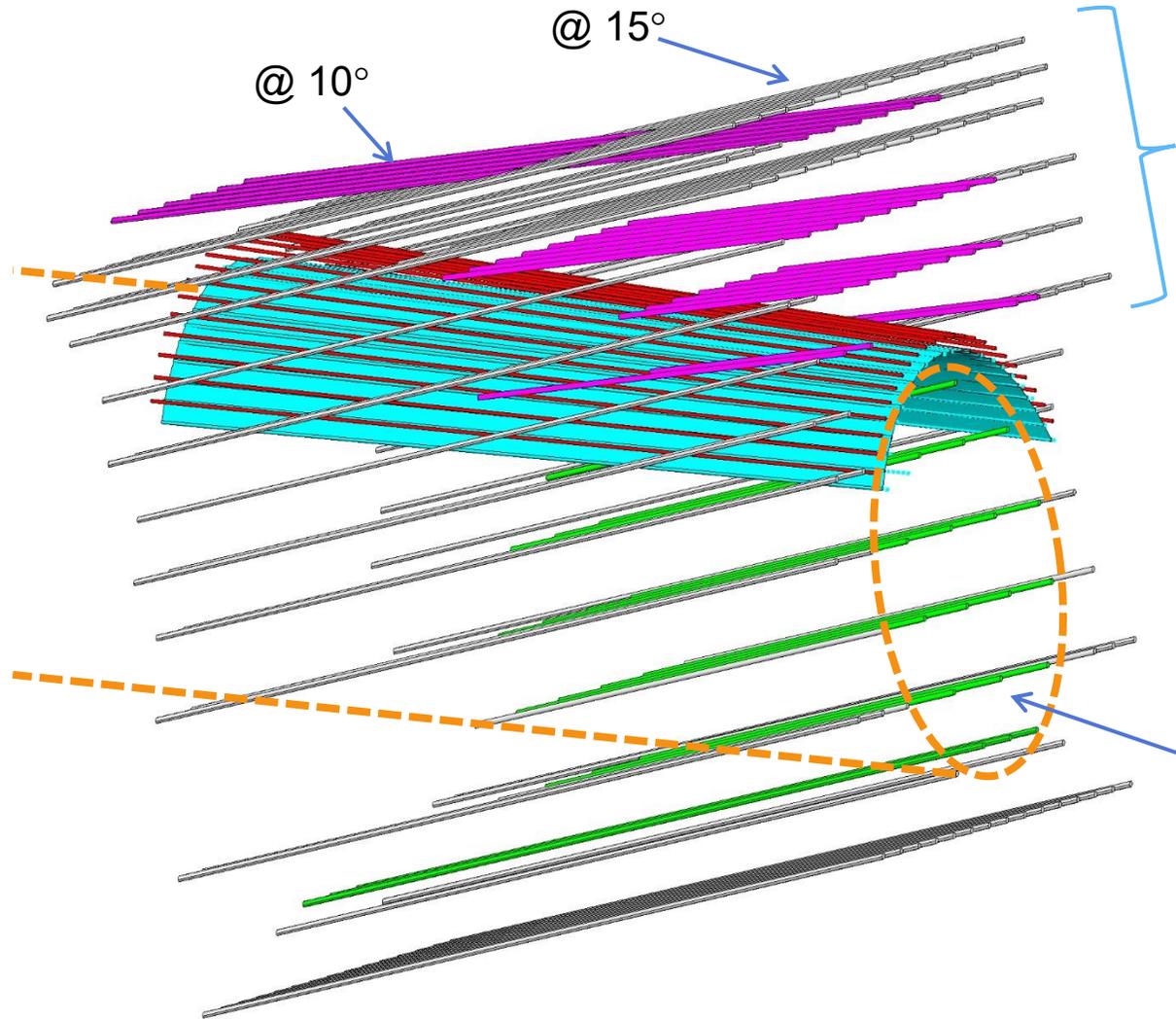


Soil Nail Facing Design



DEVELOPED ELEVATION ON HEADWALL FACING DETAILS

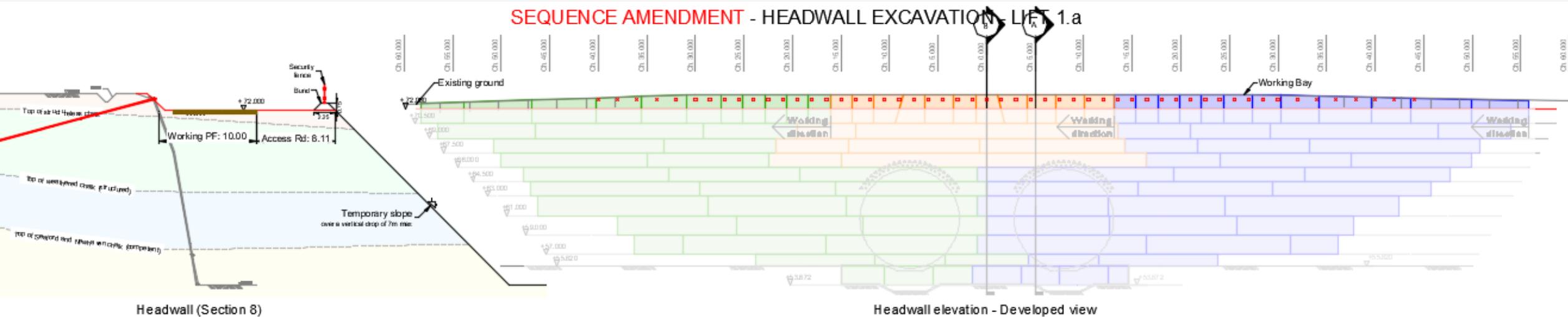
Tunnel Eye Section – Space Proofing



Steel soil nails: 32mm dia. tendon, 150mm dia. bore
6m to 20m long

GFRP soil nails, used inside eye only
38mm dia. tendon, 150mm dia. bore, 12m long, @ 15°

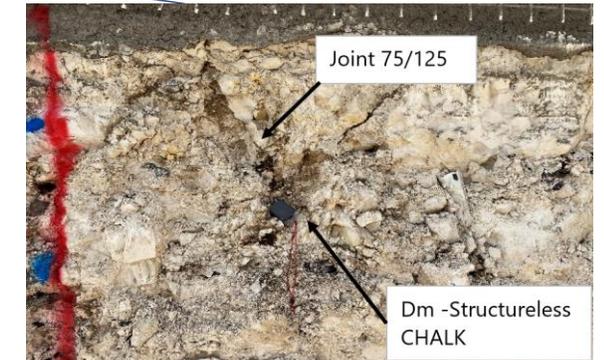
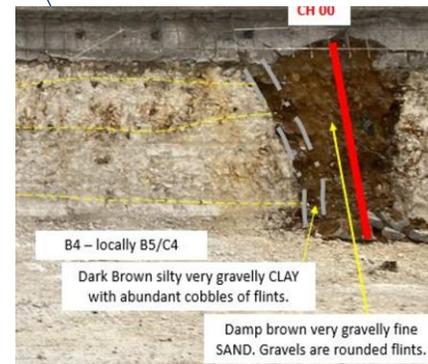
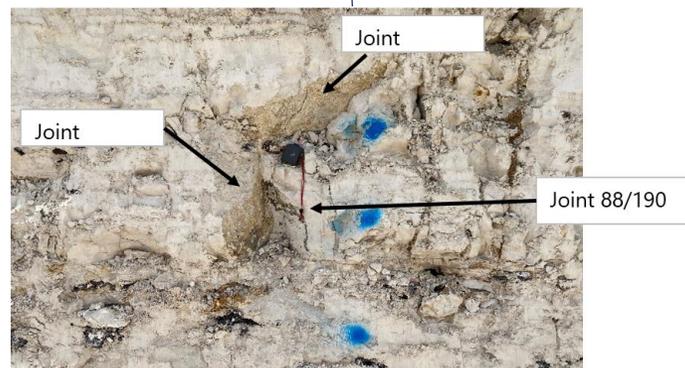
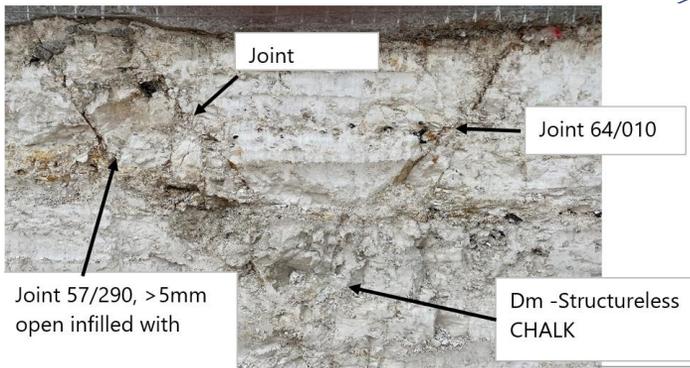
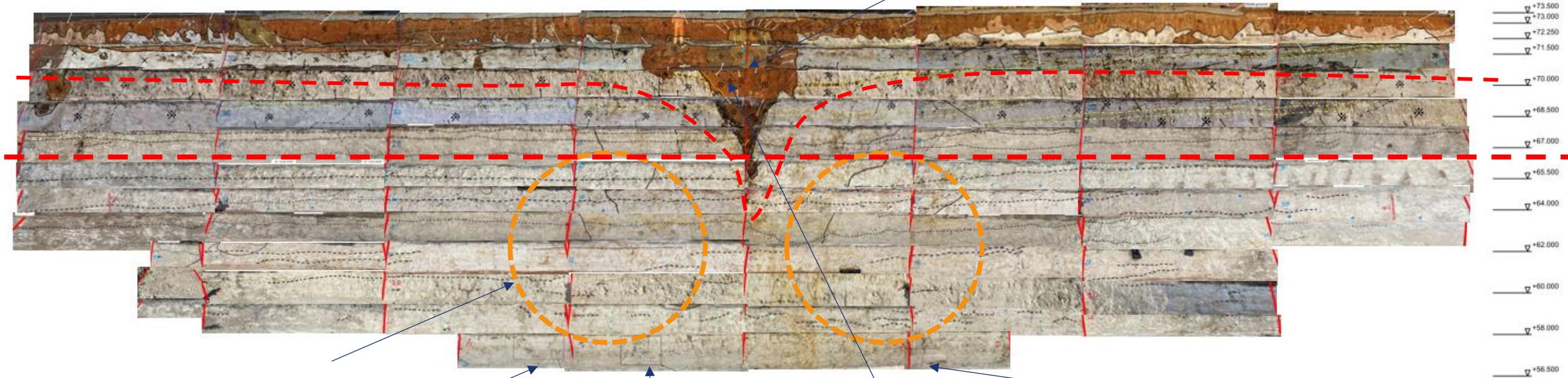
Excavation Sequence



- 1 Excavation lift per 1 row of nails (except rows B and C, i.e. 2nd and 3rd)
- Excavation → Installation of safety shotcrete (50mm) → Soil Nails → Steel mesh → Design Shotcrete → Headplates and nuts

In situ ground conditions

Solution feature at centre of headwall



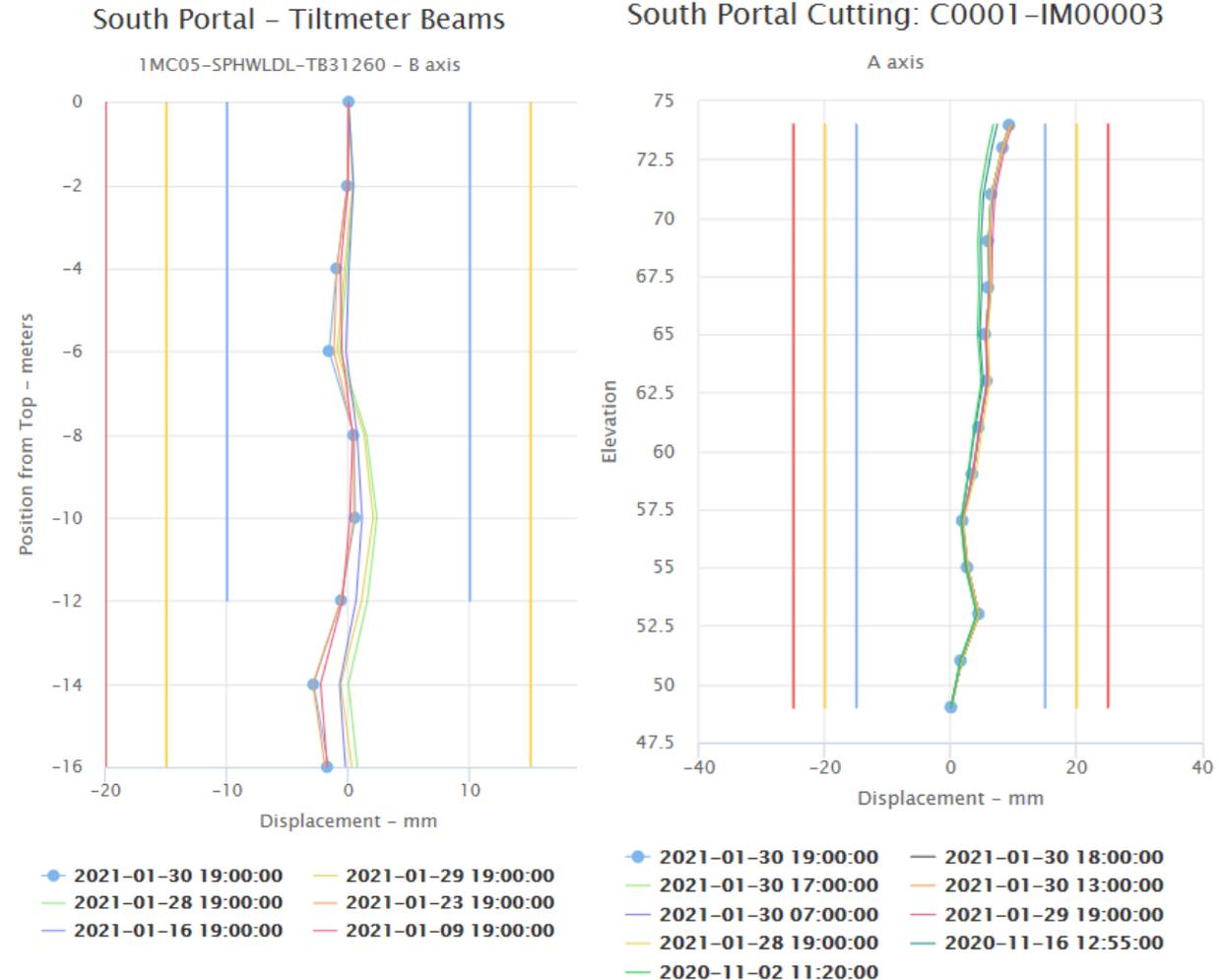
Headwall Monitoring

- 4 No. Vibrating Wire Piezometers
- 1No. **Inclinometer**
- 2 No. **Tiltmeter**

8 No. additional piezos and inclinometers in the cutting (4+4)



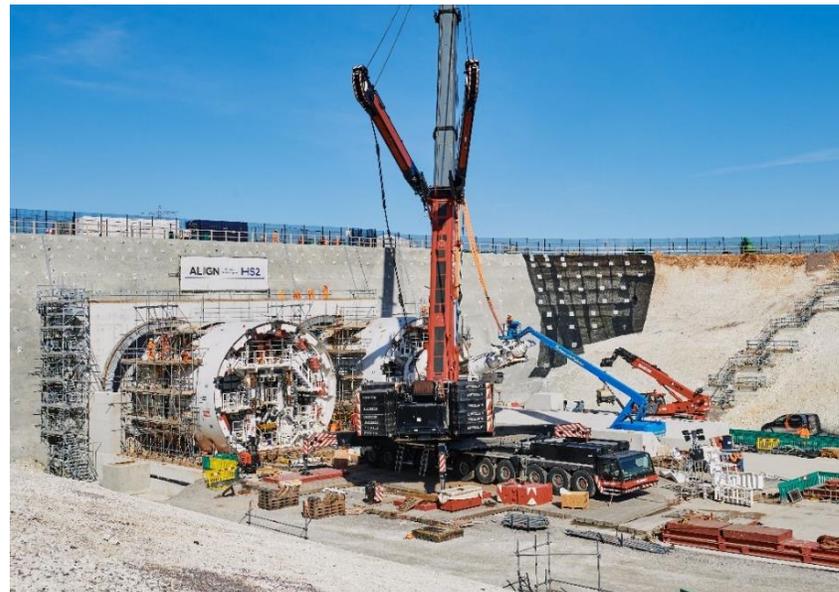
Overall movements since beginning of construction <10mm



Construction - Excavation Sequence



Construction - Excavation Sequence



South Portal – TBM Launch



Both TBMs (Florence & Cecilia) launched in Q2 2021 - The whole team celebrated the launch of Florence in May, closely followed by Cecilia in June 2021

North Portal – TBM Breakout



TBM, Florence, breaks through in February 2024 whilst TBM, Cecilia, breaks through in March 2024



ALIGN HS2



Chiltern Tunnel
Breakthrough
Florence

ALIGN H52

16km Chiltern Tunnel
Breakthrough
Ceolra

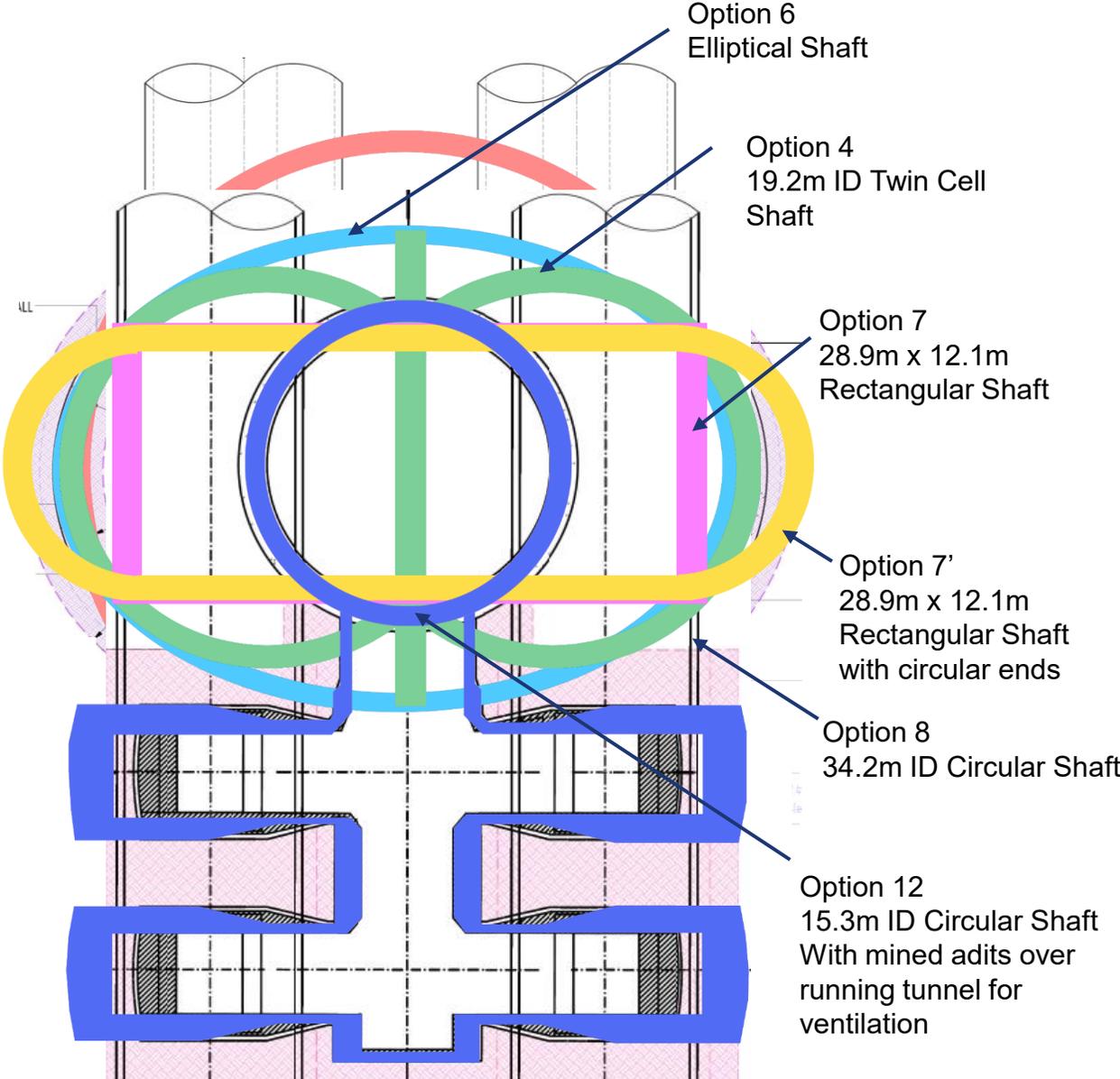
ALIGN H52



SHAFTS

- *Chalfont St Peter,*
- *Chalfont St Giles,*
- *Amersham,*
- *Little Missenden*
- and
- *Chesham Road*

The Challenge – Selecting the Best Shaft Option



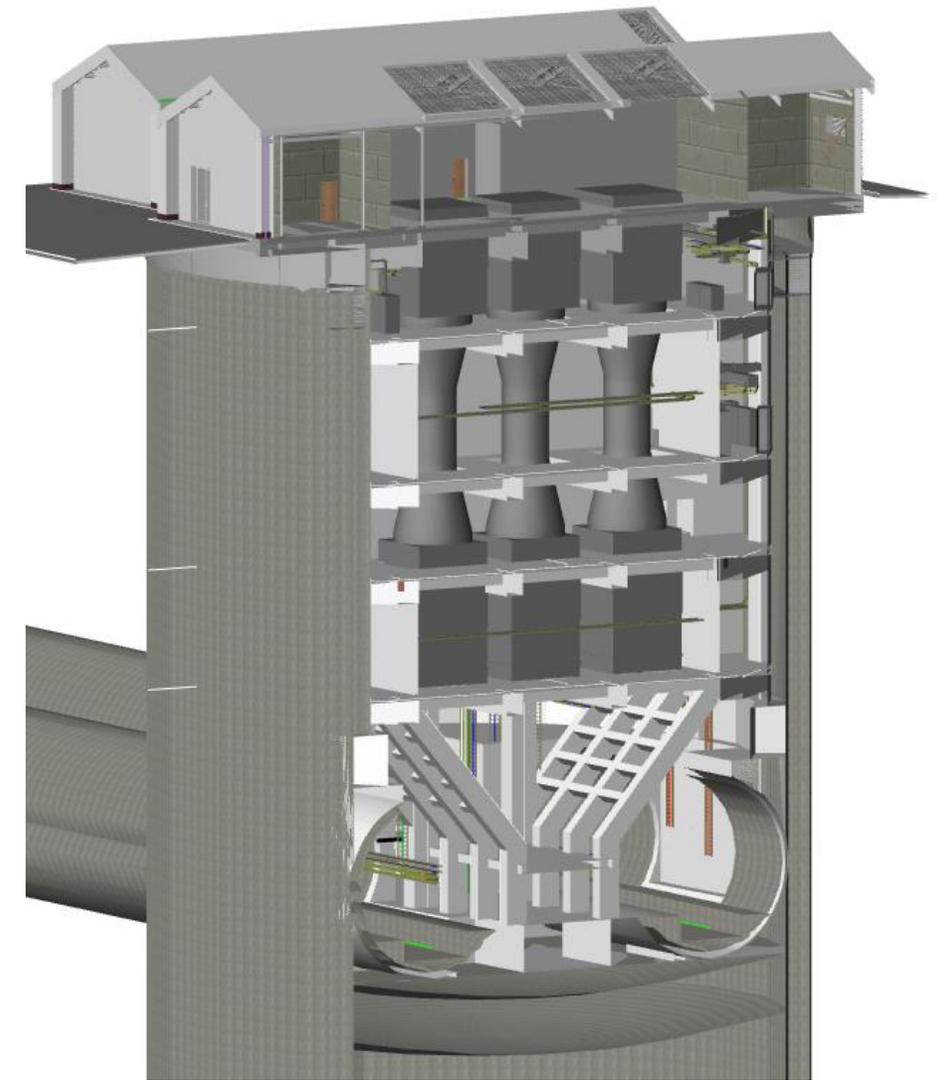
Option 8 – Traditional Shaft

Advantages

- Close Tunnel Centres
- Simple to design
- Some ground risk due to the diameter and ground conditions

Disadvantages

- Large excavation and construction material volume and embodied carbon
- Impact on local community from vehicle movements
- Not suitable for St. Peters as shaft depth (80m D-walls) and construction duration would delay the TBM



Option 8

34.2m ID Shaft

Chalfont St Giles, Amersham & Little Missenden Shafts

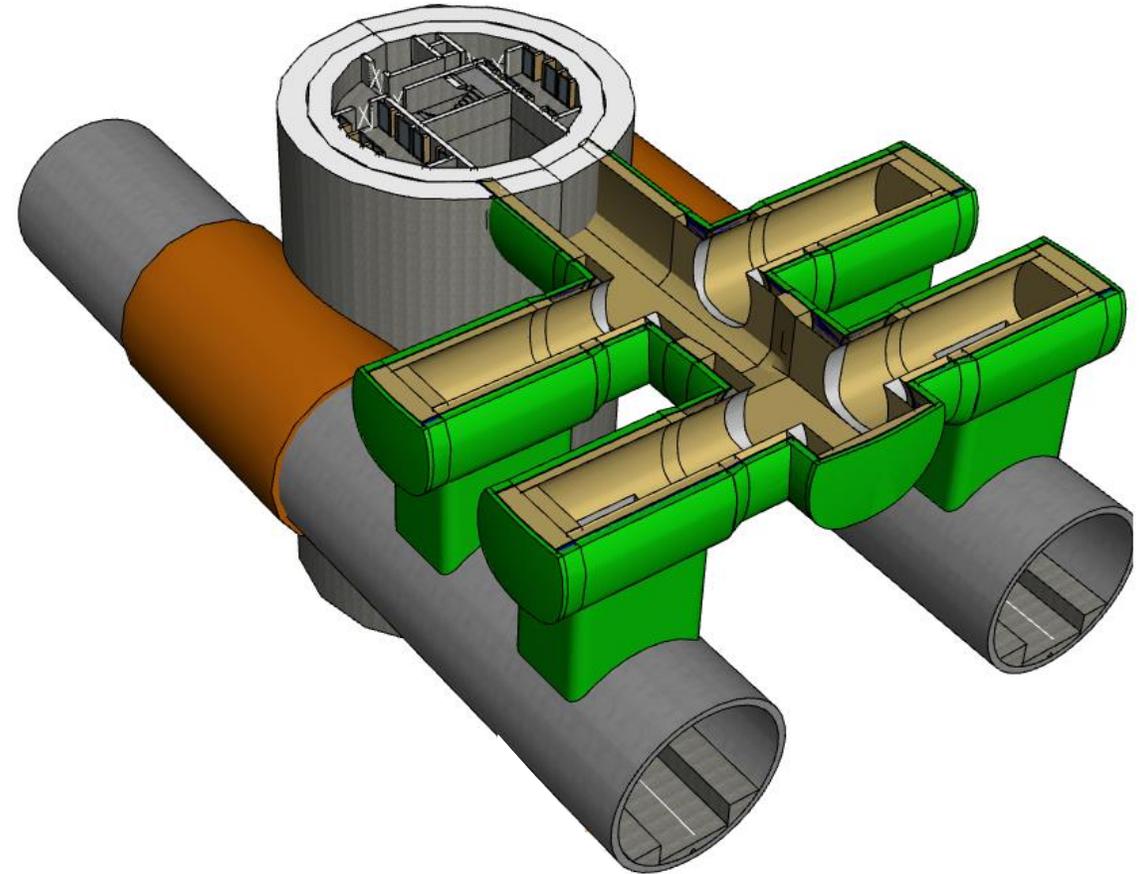
Option 12 – Shaft Innovation

Advantages

- Innovation – tunnel cuts through side of shaft allowing close tunnel centres and shorter cross passages
- Faster construction time, finished before TBM arrives
- Reduced excavated material volumes, construction materials and embodied carbon

Disadvantages

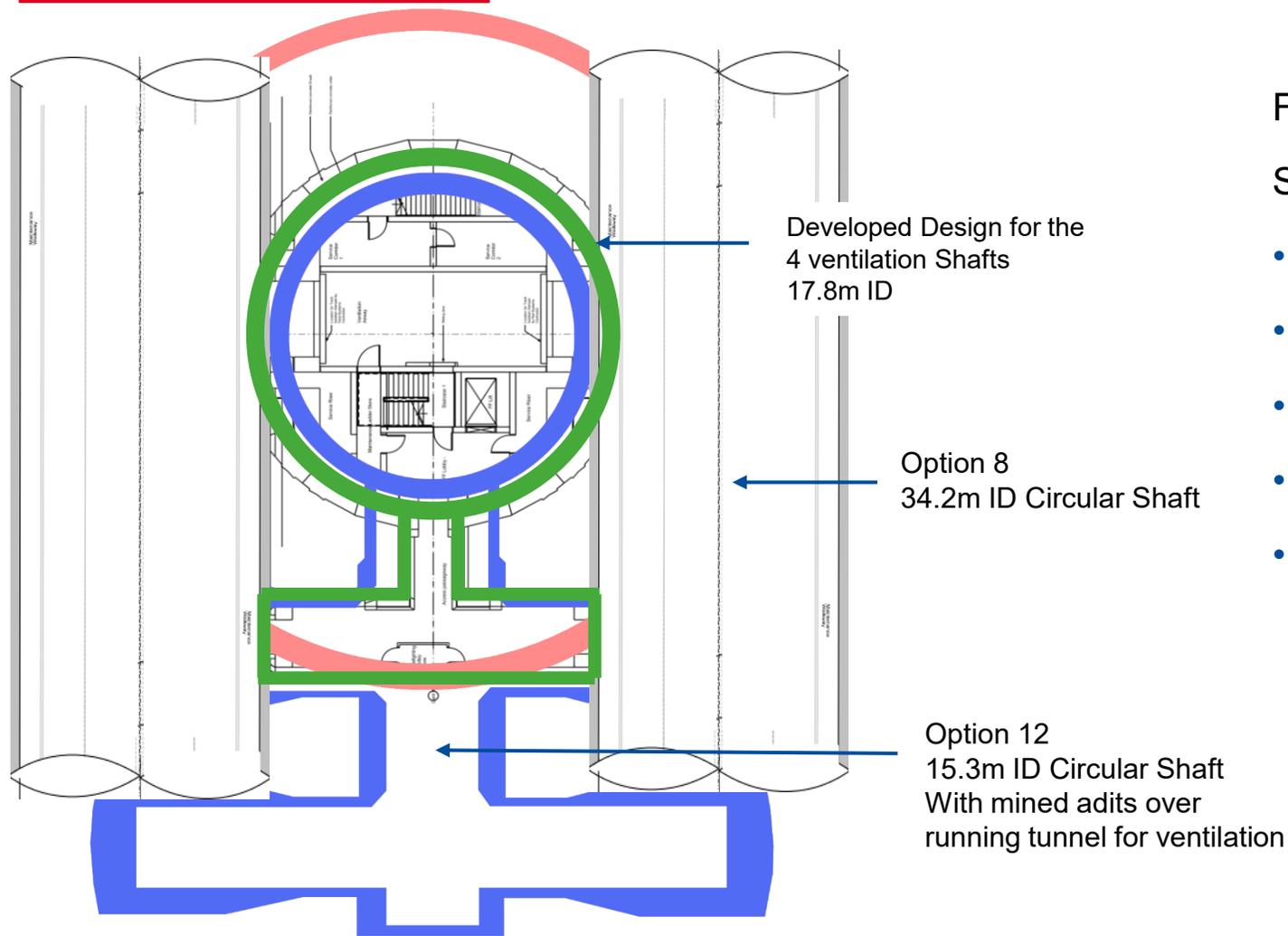
- Large complex ventilation adits required, not achievable in complex ground
- Solution would only work for Chalfont St Peters deep shaft



Option 12

15.3m ID Shaft with mined adits (ventilation fans accommodated within a shallow basement)

New / Innovative Design Solution



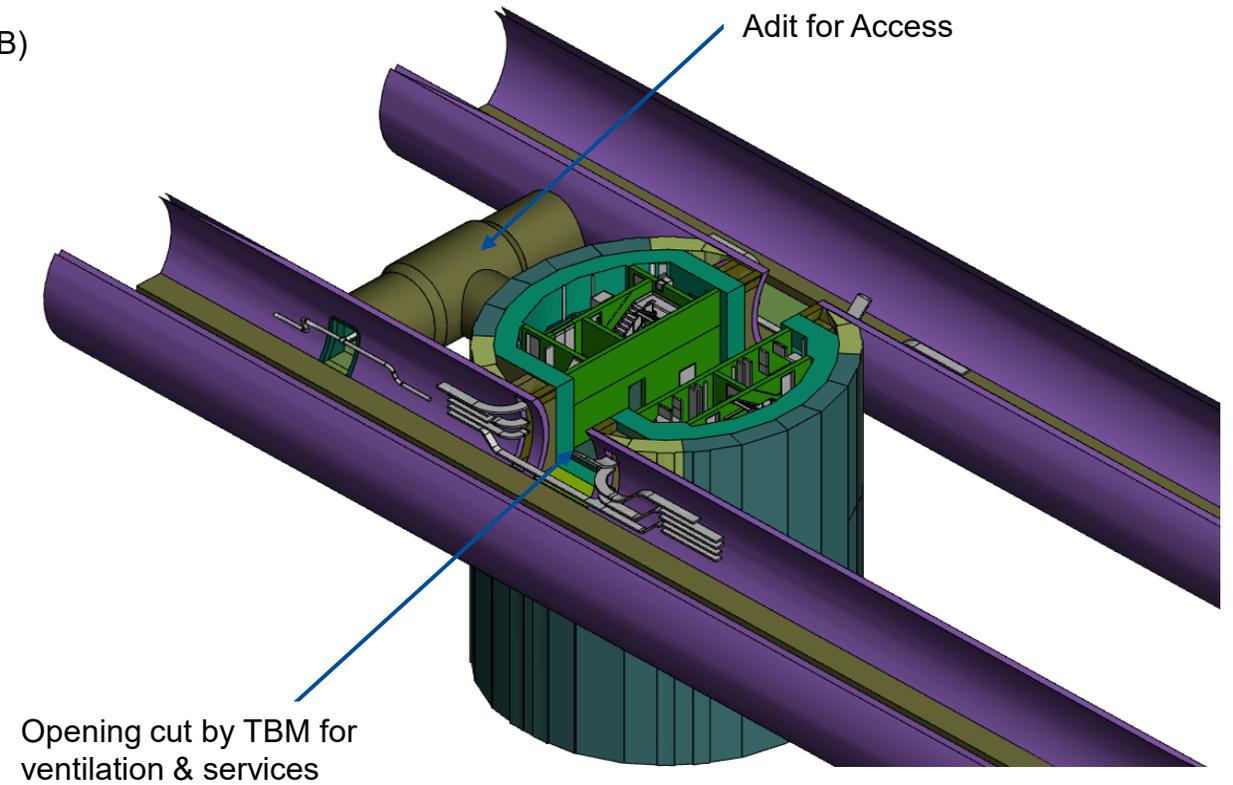
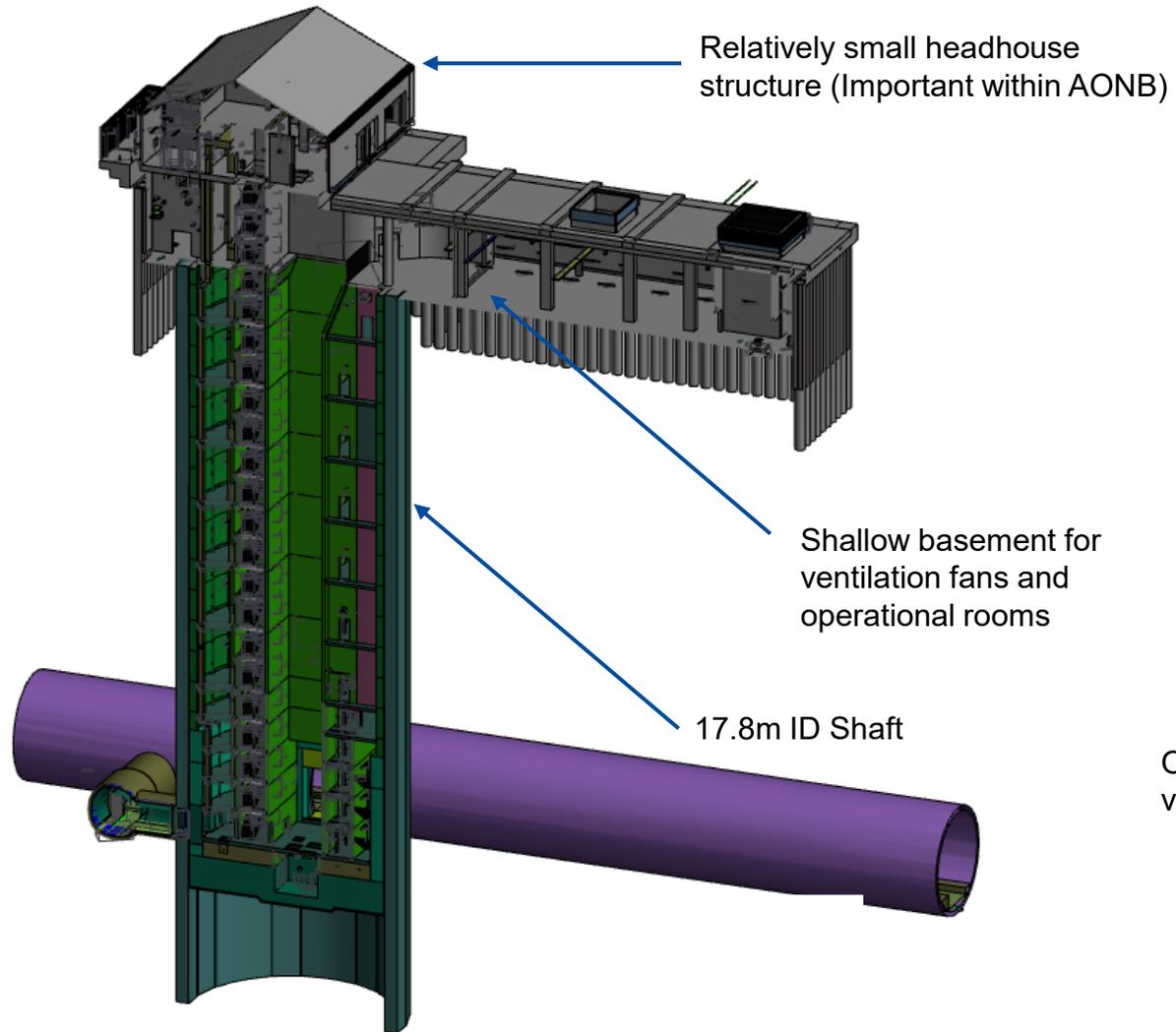
First of a kind design for UK!

Savings compared with initial developed options:

- 49% saving in excavated spoil volume
- 39% saving in concrete volume
- 20% saving in construction costs
- 27% reduction in carbon
- Benefits to construction in standardisation and modularisation of the four ventilation shafts



New / Innovative Design Solution





SHAFTS - DESIGN

Ground Investigation

Ground Investigation in chalk is complicated by chalk weathering and tendency to breakup during drilling. Shaft design required clear identification of chalk condition:

- Completely weathered chalk soil
- Weathered chalk with some structure but open / infilled joints
- Competent chalk with closed fissures
- Geological fault zones & dissolution features

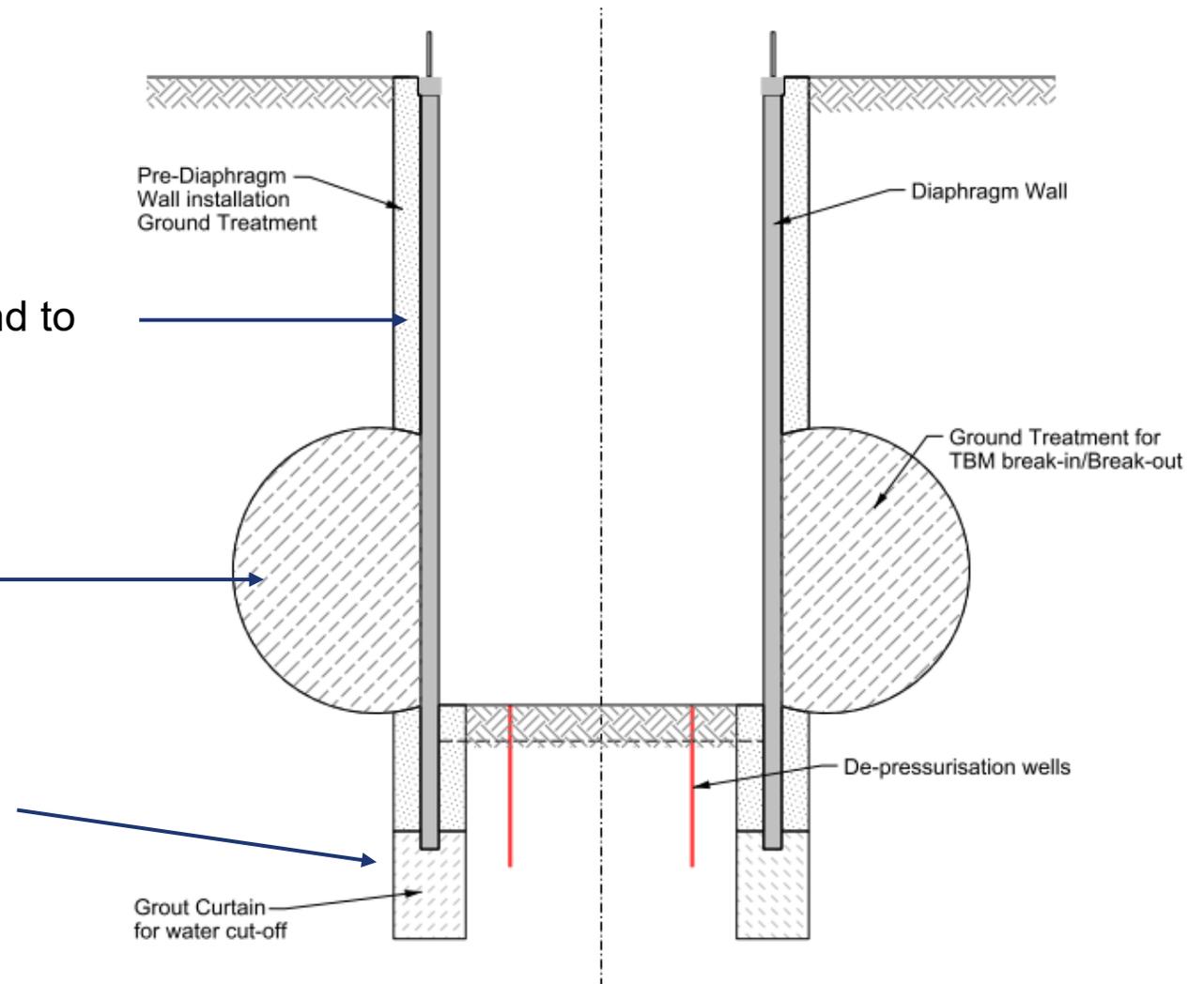


Chalfont St Giles
fault valley



Ground Treatment & Groundwater Control

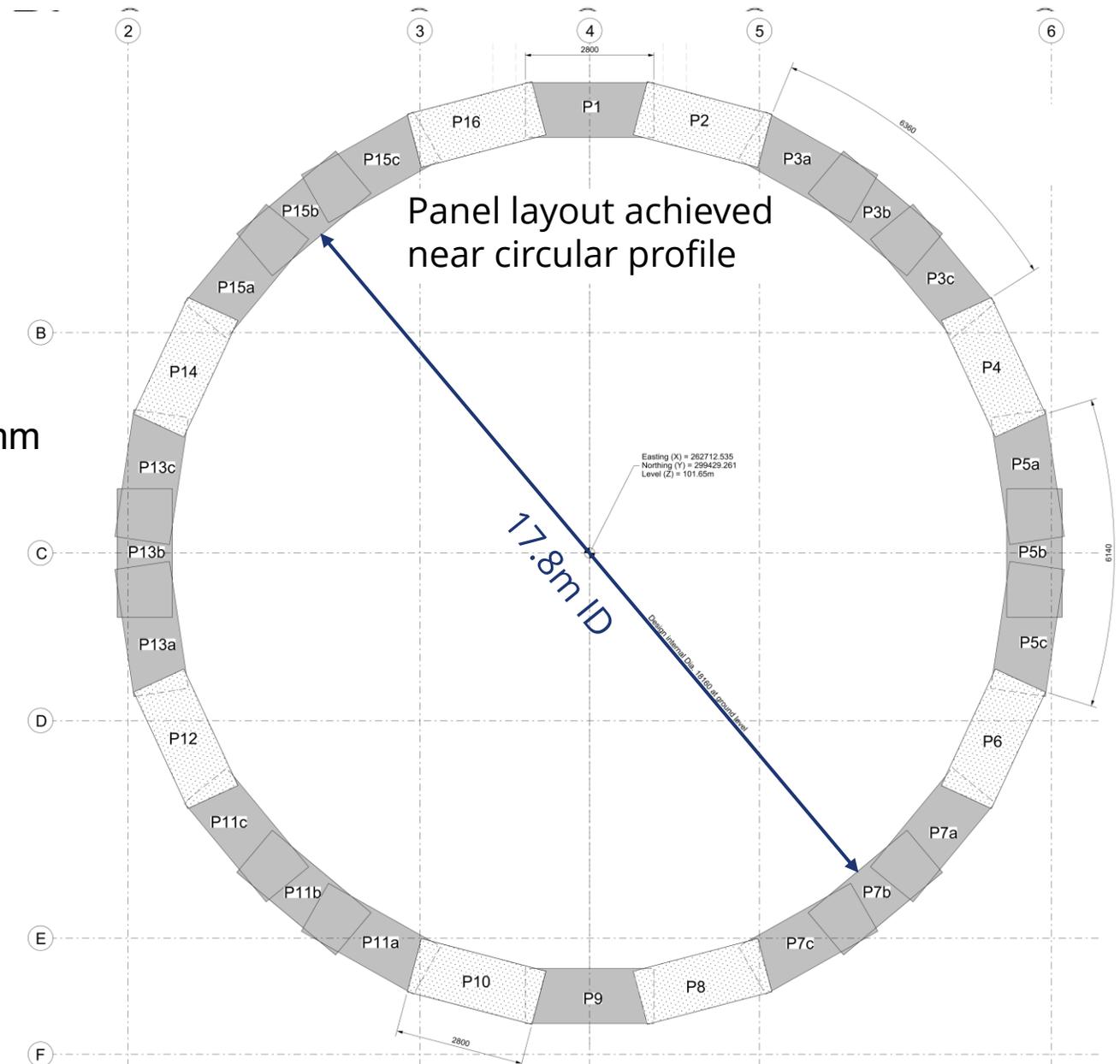
- Pre-Dwall installation Grouting to fill any voids and to stabilise the ground
- Grouting for TBM Break-in/Break-out
- Grouting for Water-cut off during construction



Groundwater Control Measures at Chalfont St Giles Shaft

CSP D-Wall Arrangement

- Design developed in collaboration with KVJV
- Diaphragm Wall Depth: 78m
- D-wall thickness: 1.2m
- Construction tolerance 1 in 400 vertical plus 25mm positional
- I&M comprised:
 - Inclinometers within D-Walls ●
 - Surface monitoring points ◆
 - Vibrating wire strain gauges ●
 - Vibrating wire Piezo-meters
 - Trigger values determined by design



Actual v Predicted

Hoop forces are key to shaft stability

Geotechnical design set instrumentation trigger values

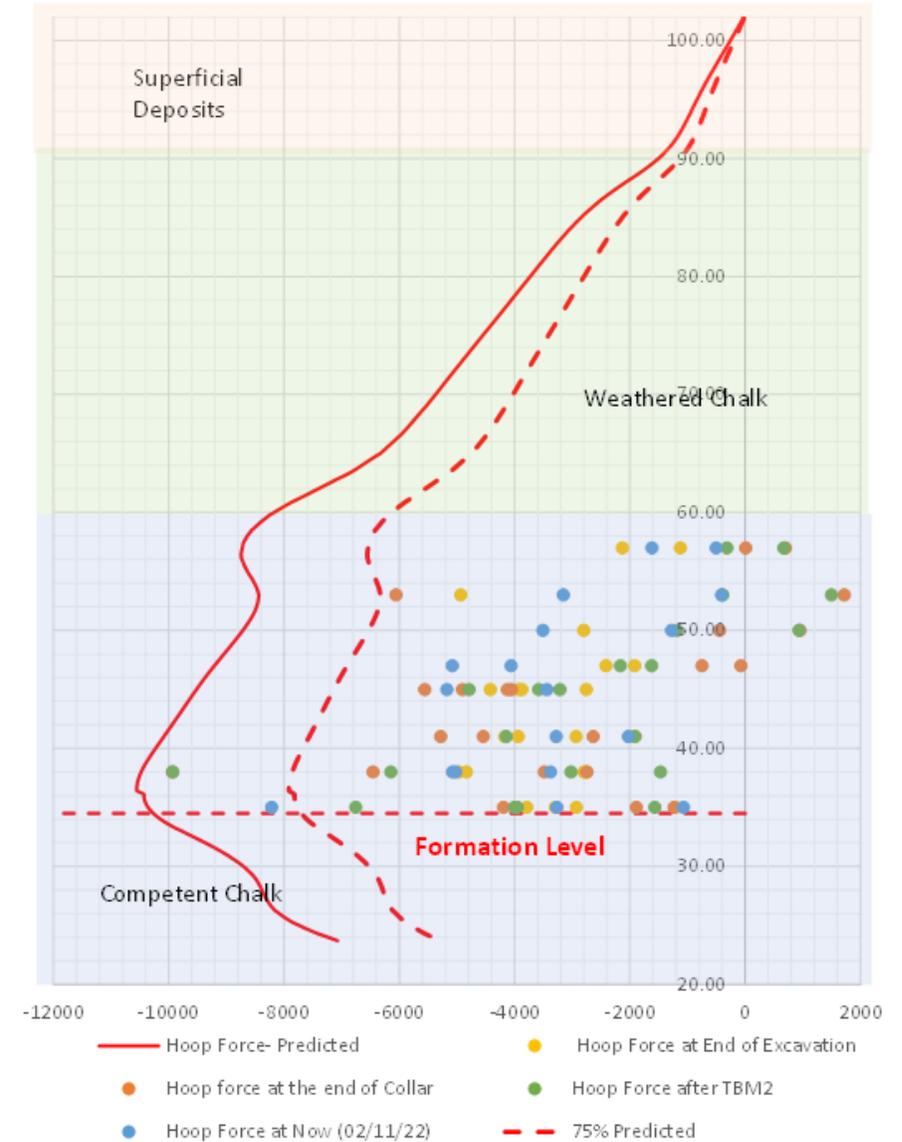
- Stresses
- Strain

Monitoring demonstrated:

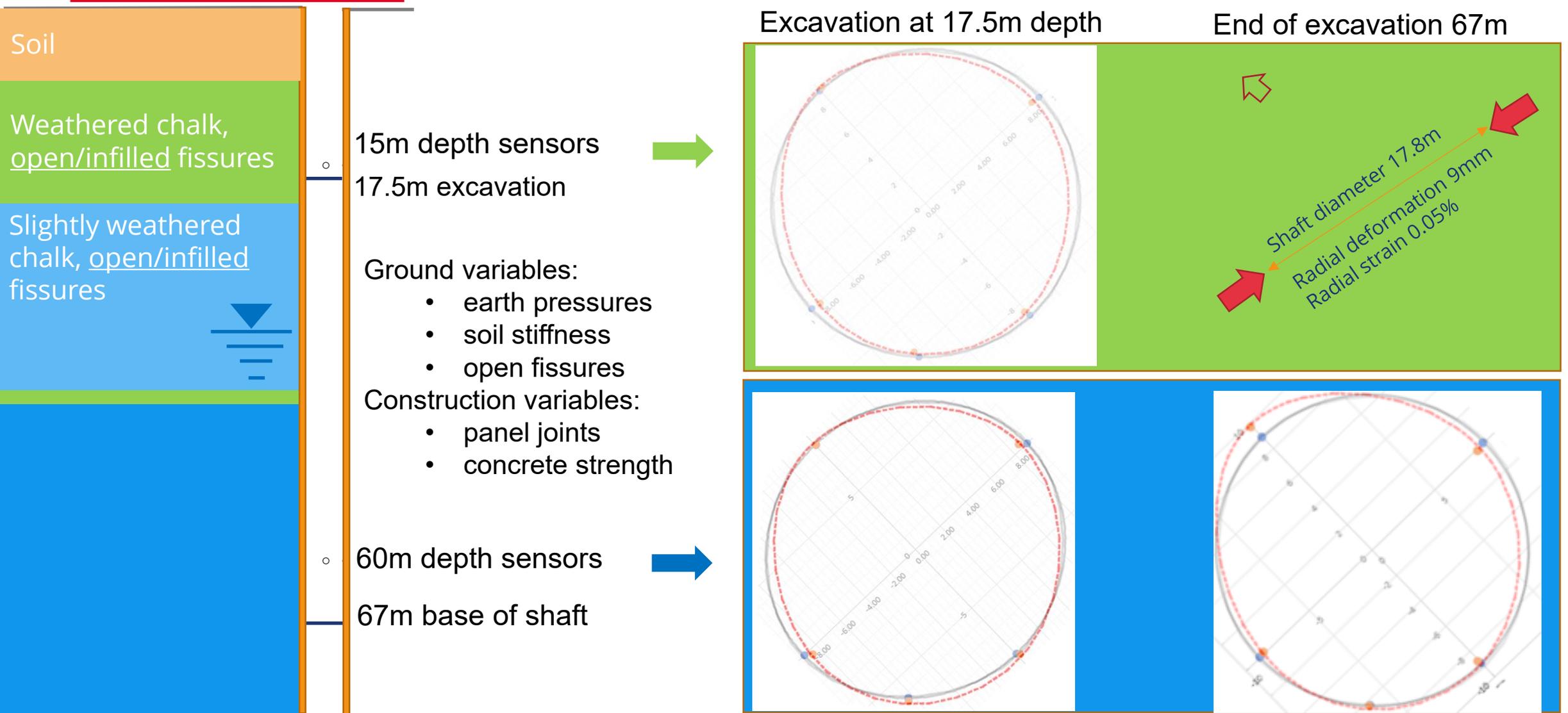
- compliance with trigger values
- also validated the design parameters used

$$K_{0-3} = \sigma'_h / \sigma'_v = 1.05 \text{ effecting the shafts during excavation}$$

- provides data for research & development



Deformed shape 1:250 exaggeration



Construction



Little Missenden



Amersham

Construction



Chesham Road



Chalfont St Peter

Construction



Chalfont St Giles



PORTAL & SHAFTS: CONCLUSIONS

Construction

- ❑ Fully integrated and collaborative team identified innovative design solutions
- ❑ Geotechnical design was fundamental to delivery of the vision
- ❑ Collaborative approach delivered significant benefits in terms of cost, sustainability & programme
- ❑ A UK first design, with significant benefits that can be transferred to other civil engineering tunnelling
- ❑ Careful planning enabled delivery in time for the TBM launch (despite Covid!)
- ❑ Recorded ground movement was within the predicted range
- ❑ No significant design change required during construction
- ❑ Construction works delivered safely



Any Questions?