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A member of the Bouygues Construction group

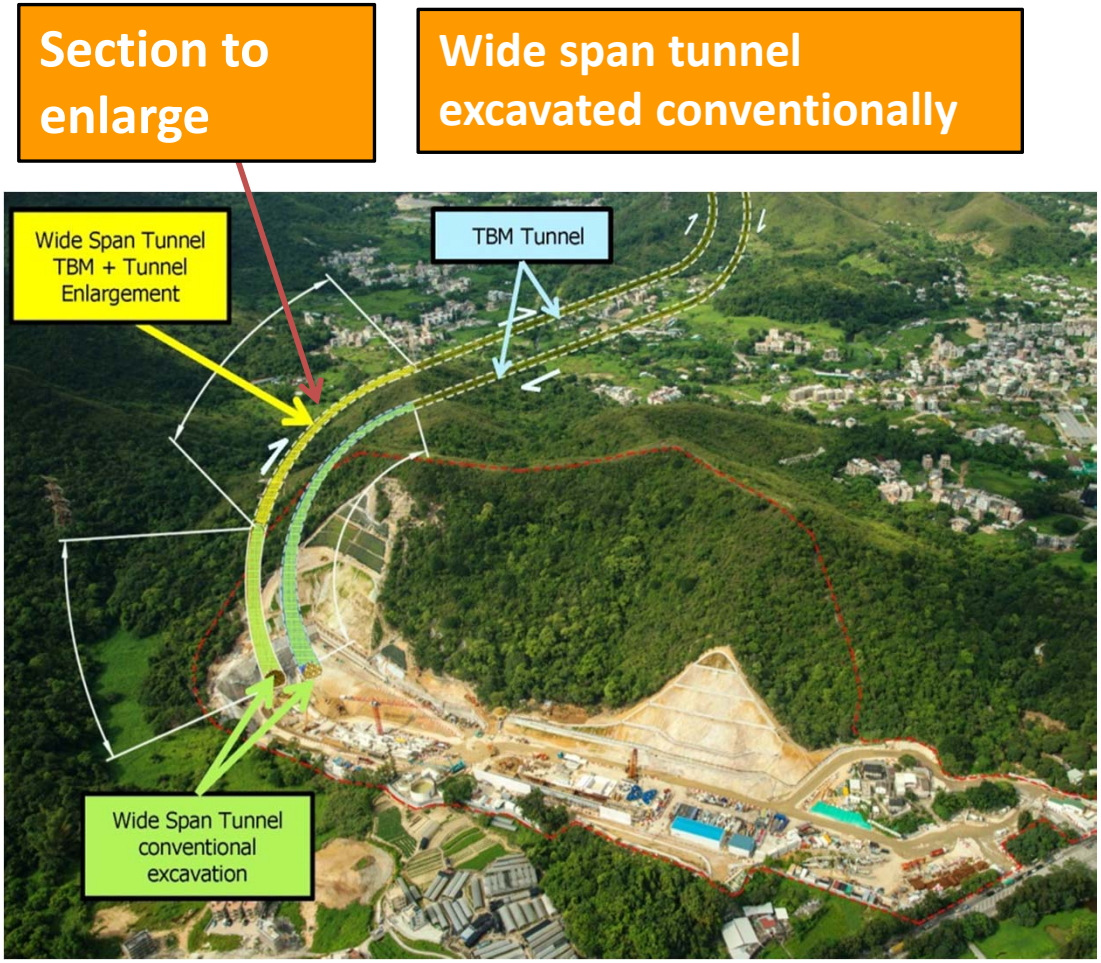
DEVB

Temporary Works Excellence Award 2017
Presentation

Contract No. CV/2012/08
Liantang / Heung Yuen Wai Boundary Control Point Site Formation and Infrastructure Works – Contract 2

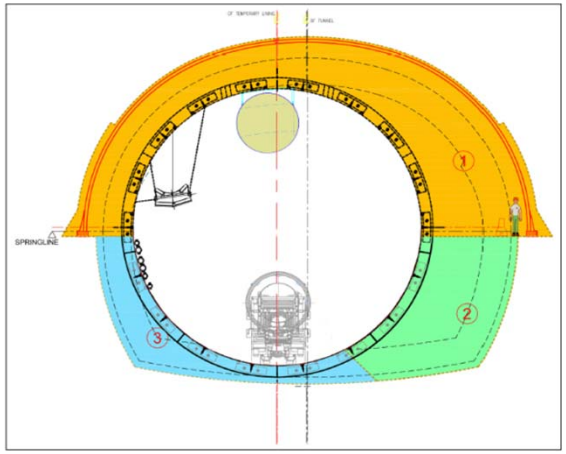
Temporary Work for Tunnel Enlargement Excavation

The Largest Scale Enlargement on the Curved Princess Hill Section

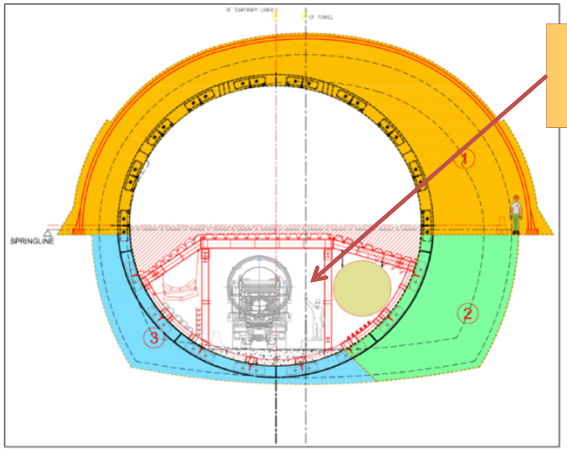


- ✓ First of this kind to enlarge from a TBM driven Tunnel to wide span tunnel
- ✓ Temporary Works - Large Scale Platform - approx. 360m long structural steel gallery inside the tunnel maintaining uninterrupted logistics supply, utility services, ventilation, spoil conveyor from TBM excavation.
- ✓ Over 1,000 tons of steel
- ✓ Temporary Works - Segment catching frame and cushions was designed to minimize the impact load from falling of demolition material.
- ✓ Designated vehicles and pedestrians' accesses maintained to TBM. Physical barriers - to separate access from the demolition and excavation work
- ✓ Temporary Support - Excavation temporary support shall be installed immediately in each round of demolition and excavation to secure tunnel stability
- ✓ **15.4m (ID) span required in this curved Princess Hill section to accommodate a widened shoulder which will provide the required sight-line distance to road users**

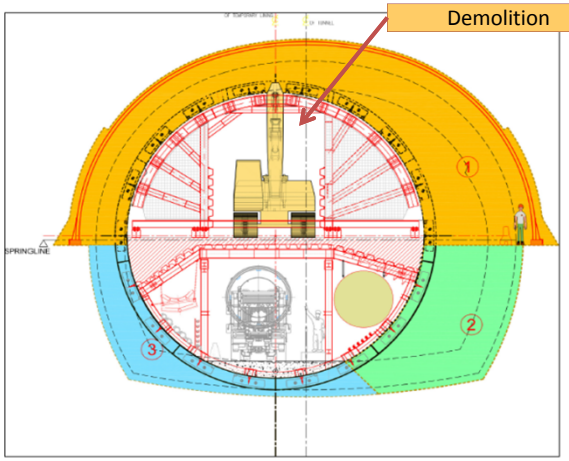
Tunnel Enlargement Sequence



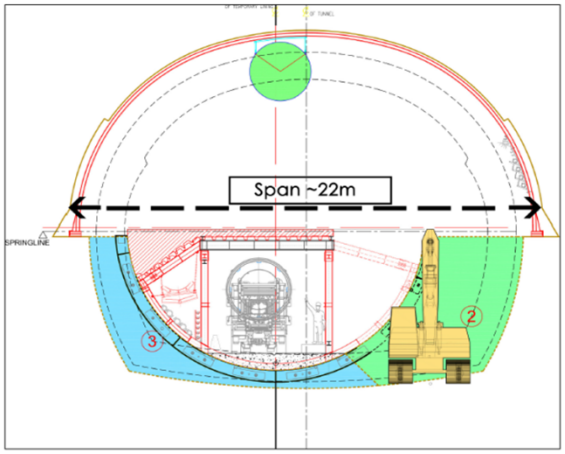
1. PILOT TBM TUNNEL BORING



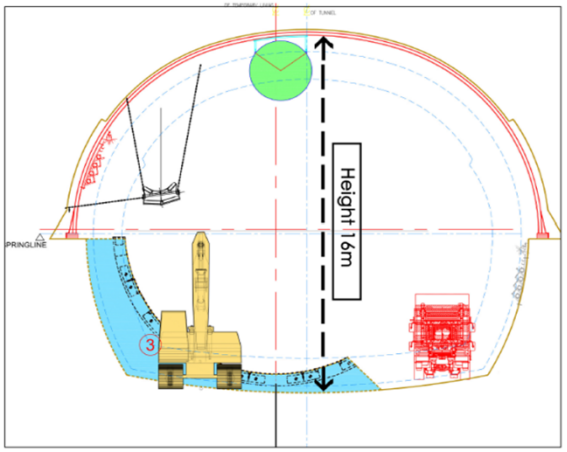
2. TEMPORARY WORK SERVICE GALLERY ERECTION



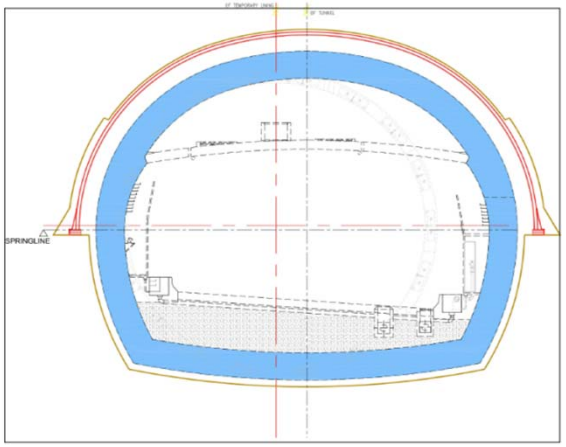
3. TOP HEADING WITH TEMPORARY WORK – SEGMENT CATCHING FRAME



4. BENCH RIGHT HAND SIDE ENLARGEMENT



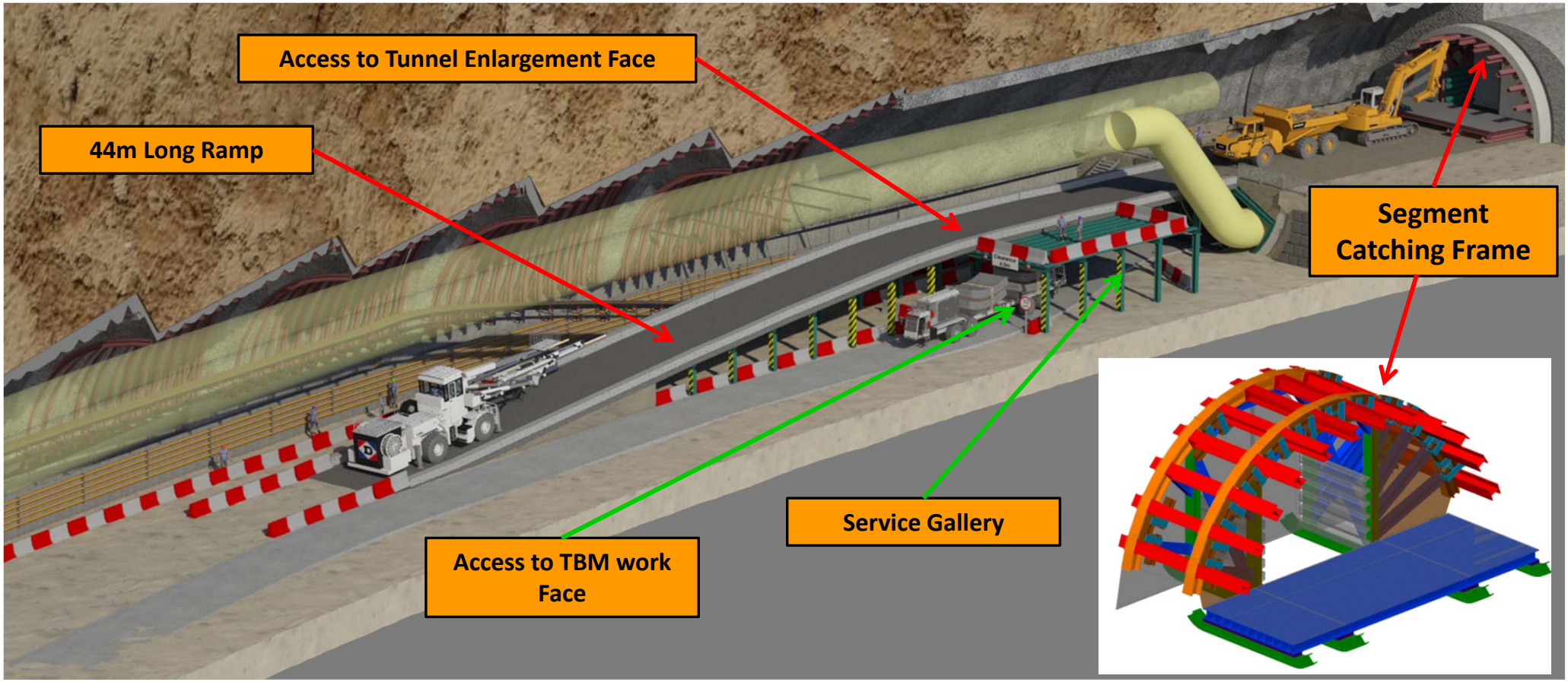
5. BENCH LEFT HAND SIDE ENLARGEMENT



6. CONSTRUCTION OF PERMANENT WORKS

Top Heading Enlargement

Accommodates multiple work faces safely into a little confined space inside the tunnel



Temporary Work for Tunnel Enlargement Excavation

Impact Test Interpolation for TBM Segmental Lining

Consider the impulse equation:

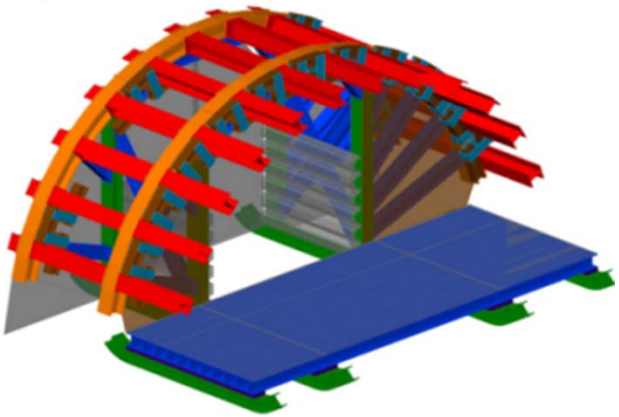
F = (mv-mu)/t, where m = mass (kg)
v = final velocity (m/s)
u = initial velocity (= zero when falling at rest)
t = impact time (s}

As u = 0, the formula is reduced to F = mv/t.

Since the impact time is unknown, reference was made to the attached test regarding impact of a 4000kg mass falling at 7.5m height onto a damping system and the first impact force is found to be around 1866kN.

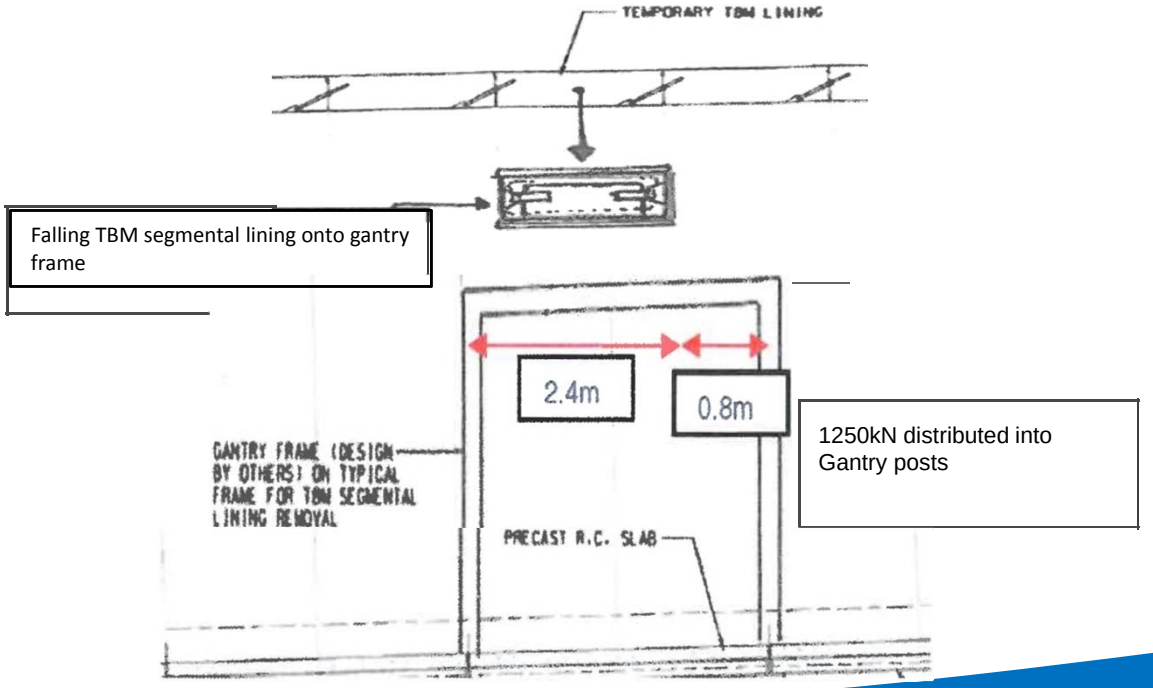
By assuming constant impact time, the force is in direct proportion with the final velocity which is determined by:

$v^2 - u^2 = 2as$, where
v = final velocity (m/s}
u = initial velocity (again= zero)
a = gravity = 9.81 m/s^2
s = travel distance (falling height) (m)
As u = o, $v = (2as)^{0.5}$



By comparing the mass of a segment and different falling height with the said test, a proportionate impact force is determined. The maximum falling height of a TBM segment is limited to 1m. The test for a 4000kg object utilizes 7.5m falling height. Thus, the calculation of an object falling at 7.5m and 1m at rest will have final velocities of 12.1m/s and 4.43m/s respectively.

As the mass of the segment is 9136kg, by comparing with above test result, the impact force produced by a segment falling at 1m height will be 1866kN x 9136/4000 x 4.43/12.1 = 1591kN. Assume loading to fall at quarter span of frame interval (0.8m from end), the load distribution for a column equates to 1600 * 2.4m = 1200kN. For conservative design, 1250 kN was utilized for the design load in SAP 2000.



Temporary Work for Tunnel Enlargement Excavation

Photo 1 – TBM Segmental Lined Tunnel before Enlargement

Photo 2 – The gallery provides a shelter for safe passage of construction vehicles underneath. Physical barriers added to separate vehicles from pedestrian access, and from the demolition and excavation work.

Temporary Work for Tunnel Enlargement Excavation

Photo 3 – Steel gallery is being erected inside built segmental lined tunnel

Photo 4 – Steel gallery being erected. It isolates the enlargement and demolition work face, in the upper deck, from the active access road underneath.

Photo 5 – Enlargement and demolition work face in the upper deck

Tunnel Enlargement Excavation

Photo 6 – To avoid overloading the gallery, Segment catching frame and cushions was designed to minimize the impact load. The size of falling segments could be controlled.

Photo 7 – Access Ramp to connect the enlargement and demolition work face, in the upper deck; and access road underneath to TBM.

Photo 8 – Temporary Support Installation after each round of excavation and lining dismantling.

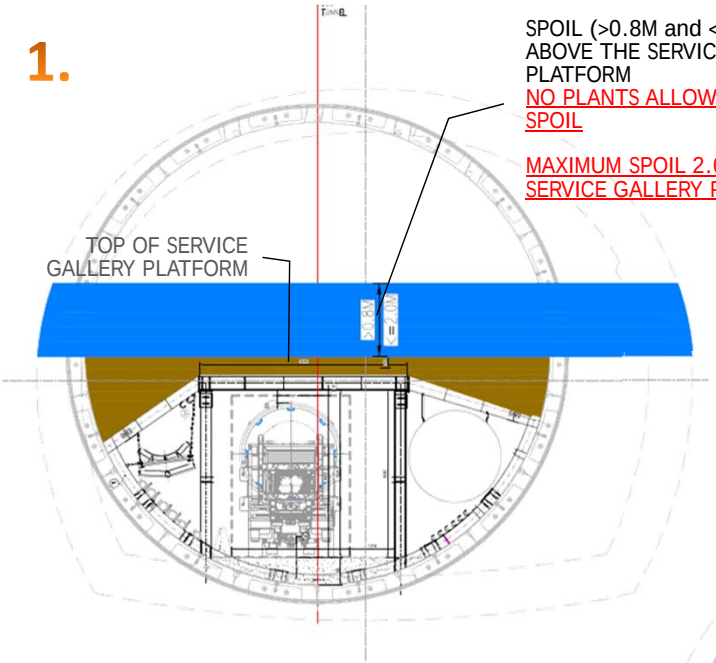
Specific Safety Controls during Work Execution

1.

SPOIL (>0.8M and <=2.0M) ABOVE THE SERVICE GALLERY PLATFORM
NO PLANTS ALLOWED ABOVE THE SPOIL

MAXIMUM SPOIL 2.0M THICK ABOVE SERVICE GALLERY PLATFORM

TOP OF SERVICE GALLERY PLATFORM

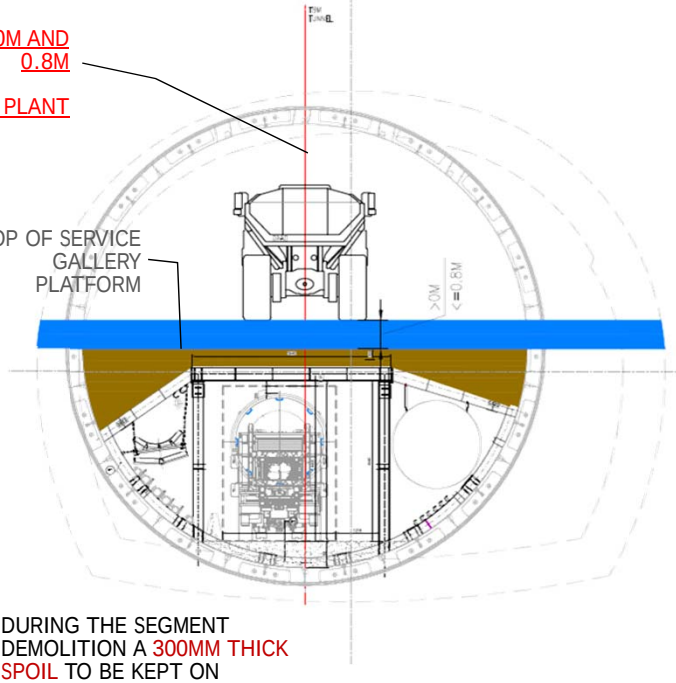


2.

BETWEEN 0M AND 0.8M

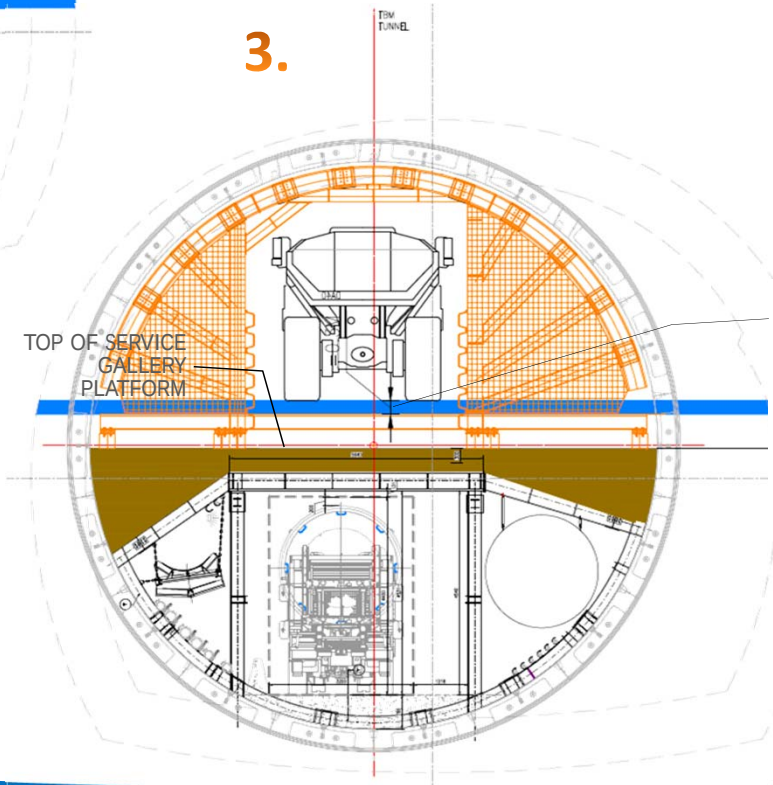
ONLY 1 PLANT

TOP OF SERVICE GALLERY PLATFORM



3.

TOP OF SERVICE GALLERY PLATFORM

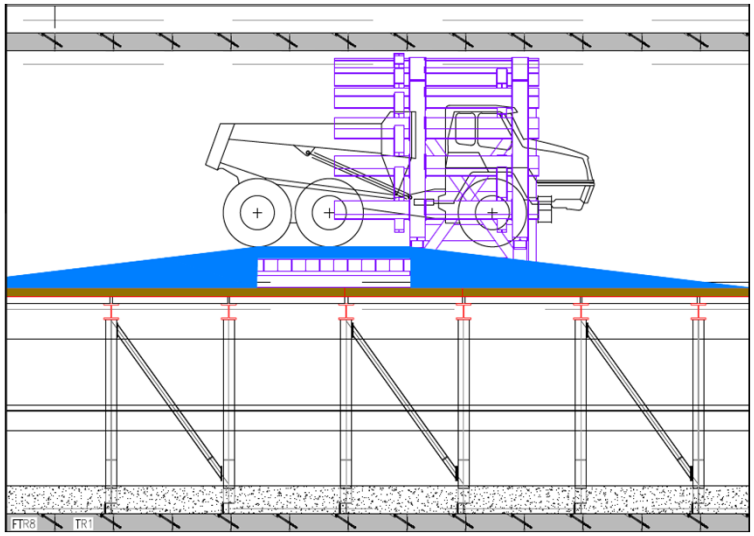


DURING THE SEGMENT DEMOLITION A 300MM THICK SPOIL TO BE KEPT ON RECEIVING PLATFORM TO REDUCE THE FALLING IMPACT

ONLY 1 PLANT AT A TIME IS ALLOWED TO PASS THE IMPACT GANTRY AREA WHEN THERE IS NO MORE THAN 300MM THICK SPOIL ABOVE THE RECEIVING PLATFORM

SAFETY ACHIEVEMENTS

Shared **innovation**



HEALTH & SAFETY A SHARED COMMITMENT!

- The top heading tunnel enlargement has been **completed safely without any incident and ahead of schedule.**
- The bench tunnel enlargement is progressing safely and smoothly.
- During the top heading tunnel enlargement, with the implementation of various safety controls, **the following risks have been well managed and mitigated to an acceptable levels**:

1. Instability of service gallery due to overloading
2. Instability of impact gantry
3. Instability of bored tunnel lining during removal
4. Excessive water ingress and ground instability during tunnel enlargement
5. Gallery frame deformation, damage of members and connection during and after segmental lining removal
6. Damage to TBM utilities, conveyor belt and ventilation duct
7. Service gallery and workers hit by moving plants
8. Workers and plants hit by flyrocks

Thank you