CONSTRUCTION OF THE VENTILATION SHAFTS AT WESTCONNEX M4-M5 LINK TUNNELS – ST PETER'S INTERCHANGE

LOCATION: ST PETERS, SYDNEY NSW | CLIENT: LENDLEASE SAMSUNG BOUYGUES JV

KEYWORDS

Construction, Tunnel, Civil, Shaft, Excavation, Drilling, Ground Support, Rock Bolts, Shotcrete

EXECUTIVE SUMMARY

Lendlease Samsung Bouygues Joint Venture (LSBJV) are the head contractor for the construction of the M4-M5 Link Tunnels. LSBJV awarded the St. Peters Interchange MDS-10 Ventilation Shaft construction (SPI Vent shafts) to SU Tunnel and Civil Pty Ltd (SUTC)

The project involved the construction of two ventilation shafts in a short timeframe. Excavation was in hard shale material and the use of innovate plant solutions assisted in the successful delivery of the project.

These plant innovations provided many advantages including safety benefits, reduced manhours on-site, reduction in program duration and greater certainty of cost.

INTRODUCTION

LSBJV awarded the St. Peters Interchange MDS-10 Ventilation Shaft construction (SPI Vent shafts) to SU Tunnel and Civil Pty Ltd (SUTC) in 2020. This project involved the construction of a two ventilation shafts. Each shaft was 10m deep with the East Shaft 13.1m (L) x 6.5m (W) and the West shaft 10m (L) x 6.5m (W) (tapering to 13.1m x 6.5m). The construction consisted of excavation of 1,585BCM of Shale Type1 & 2 material, installation of 577no rockbolts (4.0m and 4.8m long) and shotcreting (120m3).

This document describes the plant and equipment innovations and their use in the construction of the vent shafts at the WestConnex M4-M5 Link tunnel. It will also detail the advantages of using this equipment and the benefits associated with safety, time and cost.

CASE STUDY DETAIL

Working in a tunnel environment is challenging at the best of times. There is a high focus on "front-end" works (ie TBM and road header work) with less focus on ancillary works. Construction of shafts is also challenging. Excavation is typically difficult, working at depth with limited access and small machines.

Having experience and understanding this, SUTC developed an approach to reduce the LSBJV target program and reduce costs with better plant utilisation.

SUTC provided the plant and equipment necessary to complete works. Using their own fleet of excavators with specialised attachments and their own drill rig, they were able to offer LSBJV a complete solution with limited interfaces as opposed to using various different subcontractors.

Specialist subcontractors (including cranage, scaffolders and shotcretors) were also supplied by SUTC.

TENDER PROGRAM:

As part of the LSBJV project requirements, staging of the works were to be undertaken in 2m benches.
As the project involved the excavation and construction of two shafts, SUTC saw the opportunity to construct the shafts concurrently rather than sequentially. By doing this, SUTC were able to better utilise their plant and equipment and minimise the program associated with the works.
Based on the planned productivities for excavation and ground support works (i.e. drilling, rockbolting and shotcreting), it was determined that each of these activities took approximately the same duration for each bench. As a result, as excavation finished in one shaft, the ground support would finish in the other. Then the plant and equipment would be swapped from one shaft to the other using a 40t Franna crane. Refer to Figure 2.

Access constraints:
Located within tunnel cross-passages, shaft access was difficult. The dimensions of the tunnels were 10-13m (L) x 6.5m (W) x 10m (D) which caused small equipment to be used, small enough to be lifted in/out of the shafts by mobile cranes.
The height of the cross passages also limited the size of the crane that could be used.
With the need to provide access in and out of the shaft for workers, a hanging scaffold stair was installed and also reduced the space available within the shaft. Refer to Figure 1.

Shale material:
The material to be excavated was determined to be Shale Type 2 material (UCS between 12-20MPa). As the excavation progressed, the material got harder. Additional geotechnical testing was undertaken, and results were found to be an equivalent of a Shale Type 1 material (UCS>20MPa). Refer to Photo 1.

Noise and Vibration Constraints:
A hammering permit was implemented to minimise noise and vibration. As a result, there was a restriction to the size of excavator to 20T and size of hammer to 1.5T. Hammering was allowed between the hours of 0800 and 1800hrs. With the rock material being Shale Type 1, these hours were extended to 2200hrs, using the smaller 8t excavator and 750kg hammer.

Plant and Equipment:
With these constraints and Shale Type 2 material to be excavated, plant selection was crucial. After reviewing plant specificiations for reach and digging depth, it was determined that a 20t excavator (with an 8t excavator used for hard to reach places) could excavate the first two benches (RL 0 to -4m). For the lower three benches (RL -4 to -10m), after a crane lift study was prepared, an 8t excavator could be used and be lifted in/out using a 40t Franna crane. Refer to Photo 5.
For the lower benches, mucking out activites were planned to be undertaken using a crane and muck bin.
As the excavation got deeper, the ground got harder. With only small excavator use possible to access the shaft, larger machines were required to remove the hard rock efficiently. As a result, options were explored incluidng innovative attachments to assist in the excavation.

<u>3m Extension Arm</u>
A 3m extension arm was fabricated to allow the large 20t Excavator to hammer deeper with the 1.5t rock hammer. This assisted in the removal of the hard shale and increased production significantly. Refer to Photo 2.

<u>6m Dipper Arm</u>
Rather than using a crane and muck bin to muck out material in the lower benches (RL -4 to -10m) a 6m dipper arm was fitted to the excavator. This allowed mucking out activities to be faster, with only one operator required (rather than a crane crew) Increase in saftey with less wheeled crane movements. Refer to Photo 3.

<u>Larger Hammer</u>
A large hammer (suitable for a 13t Exc) was used as an attachment on an 8t excavator. Refer to Photo 4.

Additional Excavator

Two 8t excavators were in the one shaft to increase production. Refer to Photo 4.

Extended Work Hours

The hammer permit was modified to allow hammering with the smaller 8t excavator and 750kg hammer to 2200hrs. Shifts were split with some workers starting/finishing later. This allowed the excavation operation to work longer each day (up to 16 hours) and assisted in completion of the project.

Other Works:

Other works associated with the contract included:

Rockbolting: drilling, rockbolting, tensioning and grouting works were self performed using SUTC labour, Atlas Copco T20 drill rig, grout mixer/pump

Shotcreting: works were undertaken using a dry-hired concrete pump and specialist subcontractor as required

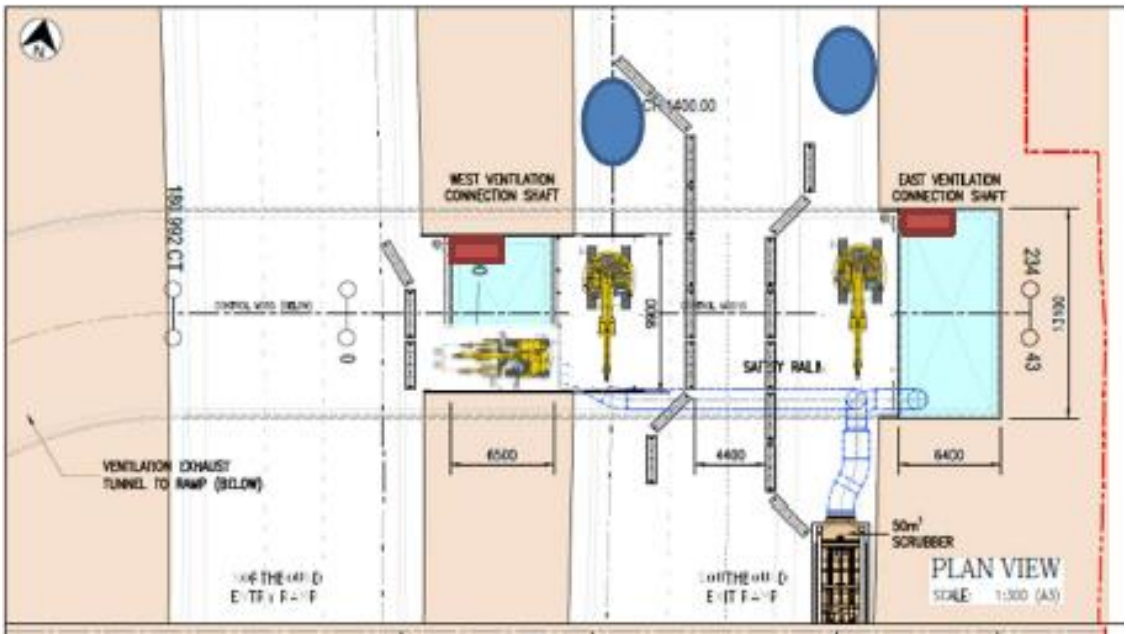
Cranage: a local cranage subcontractor was engaged as requried to lift plant and equipment

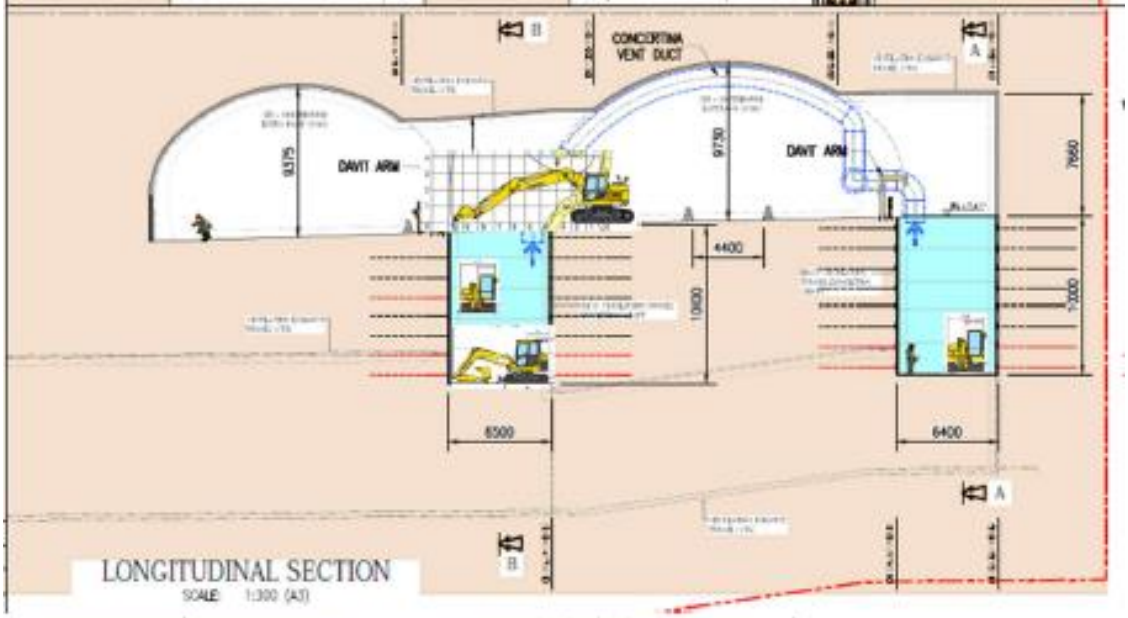
Scaffold: a local scaffolder was engaged to add stair panels as the benches were progressively excavated.

Figure 1 shows a schematic of the MDS10 ventilation shafts.

GREEN FLEET

TUNNEL AND CIVIL SERVICES™
AUSTRALIA-WIDE





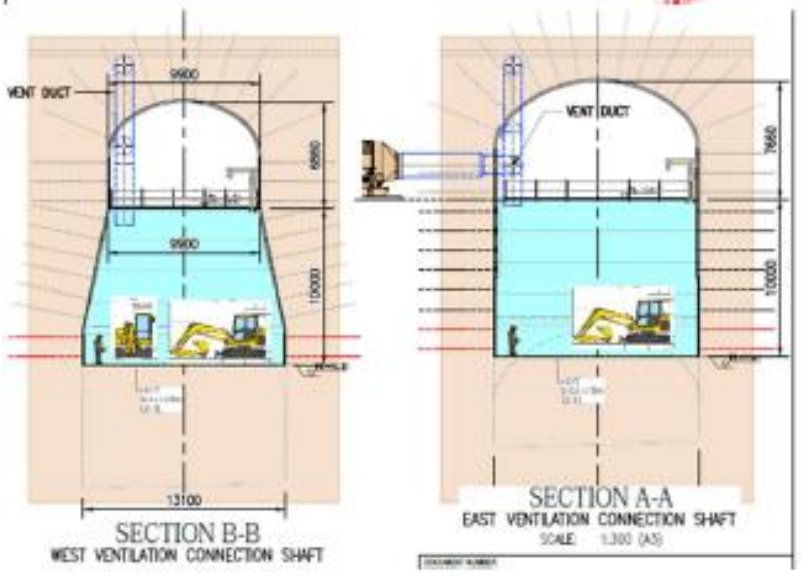


Figure 1: MDS10 Ventilation Shafts

SPI- MDS10 Vent Shafts			Wk1							Wk2							Wk3							Wk4							Wk5							Wk6					
			Day																																								
Description	Qty	Plant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Mobilise																																											
West																																											
Bench 1: 0 to -2m																																											
Excavation	135BCM	23t Exc/30t ADT																																									
Rockbolting	26no @ 4m = 104m	Atlas Copco																																									
Shotcreting (x1.3)	8.8m3	By others																																									
Bench 2: -2 to -4m																																											
Excavation	145BCM	23t Exc/30t ADT																																									
Rockbolting	52no @ 4m = 208m	Atlas Copco																																									
Shotcreting (x1.3)	9.2m3	By others																																									
Bench 3: -4 to -6m																																											
Excavation	156BCM	8t Exc/Franna																																									
Rockbolting	26no + 10no @ 4m, 24no @ 4.8m = 26(	Atlas Copco																																									
Shotcreting (x1.3)	9.6m3	By others																																									
Bench 4: -6 to -8m																																											
Excavation	166BCM	8t Exc/Franna																																									
Rockbolting	10no @ 4m, 24no @ 4.8m = 155m	Atlas Copco																																									
Shotcreting (x1.3)	10m3	By others																																									
Bench 5: -8 to -10m																																											
Excavation	170BCM	8t Exc/Franna																																									
Rockbolting	10no @ 4m, 32no @ 4.8m = 194m	Atlas Copco																																									
Shotcreting (x1.3)	10.2m3	By others																																									
East																																											
Bench 1: 0 to -2m																																											
Excavation	170BCM	23t Exc/30t ADT																																									
Rockbolting	30no @ 4m = 120m	Atlas Copco																																									
Shotcreting (x1.3)	10.2m3	By others																																									
Bench 2: -2 to -4m																																											
Excavation	170BCM	23t Exc/30t ADT																																									
Rockbolting	50no @ 4m, 12no @ 4.8m = 258m	Atlas Copco																																									
Shotcreting (x1.3)	10.2m3	By others																																									
Bench 3: -4 to -6m																																											
Excavation	170BCM	8t Exc/Franna																																									
Rockbolting	20no @ 4m, 26no @ 4.8m = 205m	Atlas Copco																																									
Shotcreting (x1.3)	10.2m3	By others																																									
Bench 4: -6 to -8m																																											
Excavation	170BCM	8t Exc/Franna																																									
Rockbolting	20no @ 4m, 14no @ 4.8m = 147m	Atlas Copco																																									
Shotcreting (x1.3)	10.2m3	By others																																									
Bench 5: -8 to -10m																																											
Excavation	170BCM	8t Exc/Franna																																									
Rockbolting	20no @ 4m, 14no @ 4.8m = 147m	Atlas Copco																																									
Shotcreting (x1.3)	10.2m3	By others																																									
QA Docs																																										

Figure 2: Program sequence of works

Photo 1: Shale Type 1 rock

Photo 2 shows the 3m extension arm with 1.5t hammer (red circle) (East#3)

Photo 2: 3m extension arm (red circle)

Photo 3 shows the 6m dipper arm used for mucking out, minimising the use of cranes/muck bin (East#4)

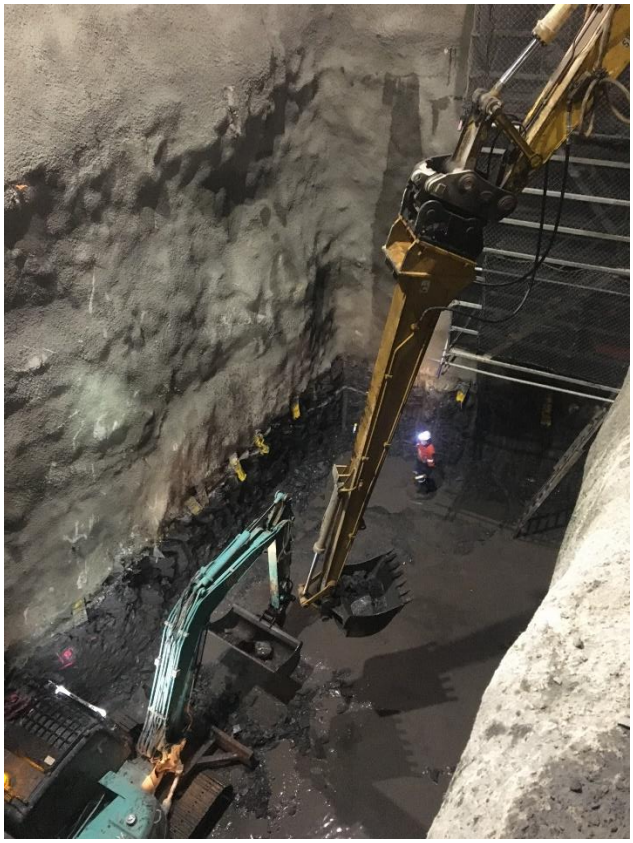


Photo 3: 6m dipper arm

Photo 4 shows two zero swing 8t excavators working in shaft with large hammer in use.

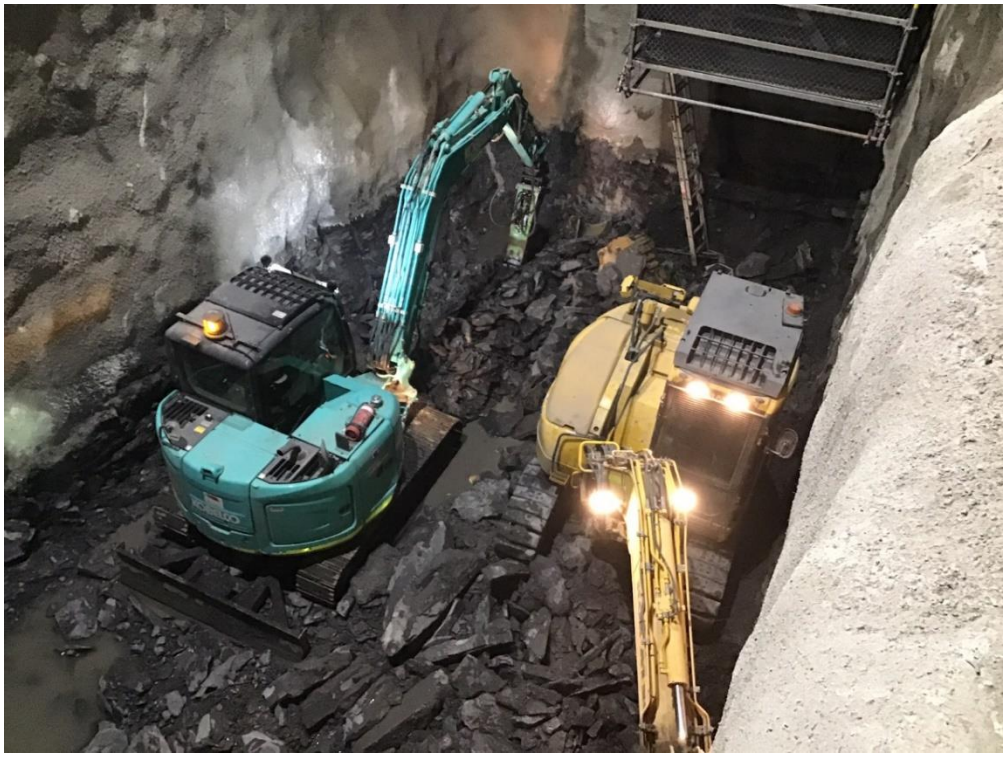


Photo 4: Two zero swing 8t excavators working in shaft with large hammer

Photo 5: 40t Franna lifting 8t excavator

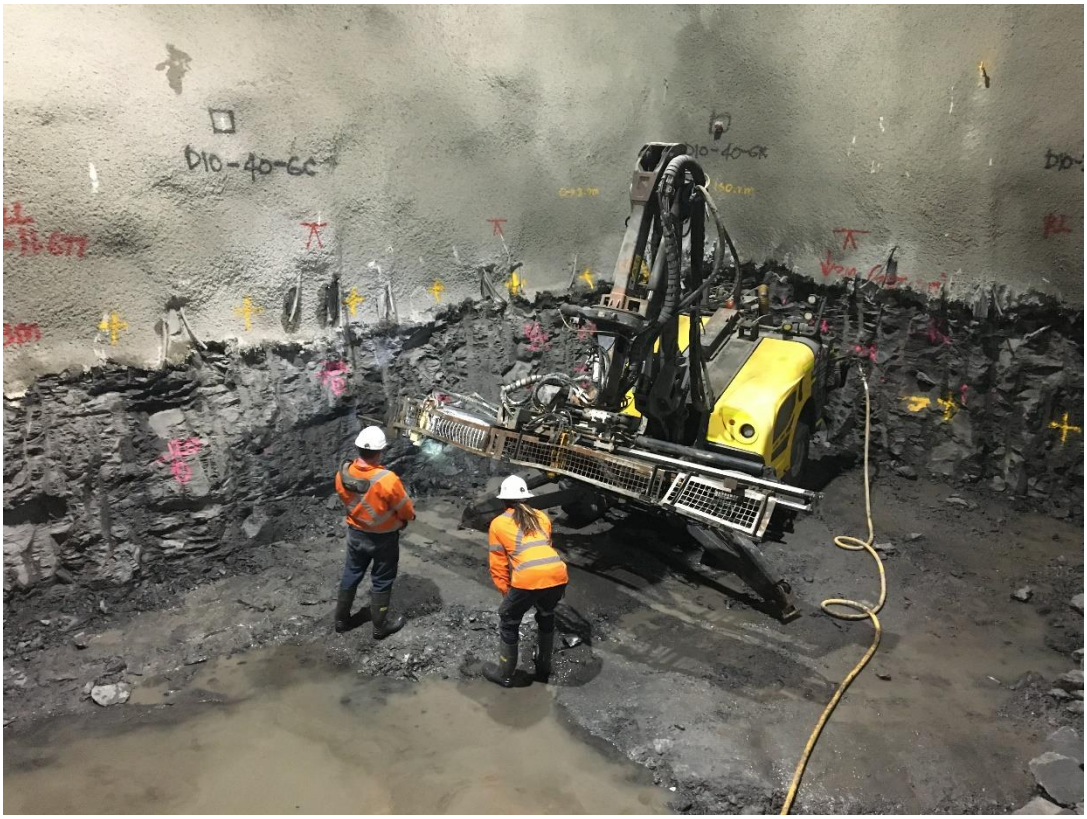


Photo 6: Atlas Copco T20 Drill Rig

Photo 6: Installed rockbolts and stripdrains

Photo 8: Shotcrete pump

Photo 9: Shotcreting spraying