ITA-AITES WTC 2020
11 – 17 September 2020
Kuala Lumpur, Malaysia

1ST SYMPOSIUM FOR YOUNG TUNNELLERS OF ASIA
12 September 2020

SYTA 2020

On blow-out in tunnelling and a case study in Hochiminh Metro Line 1

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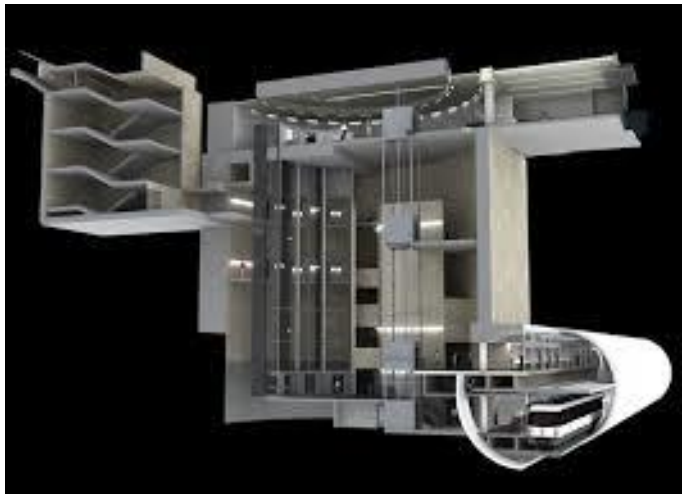
Contents

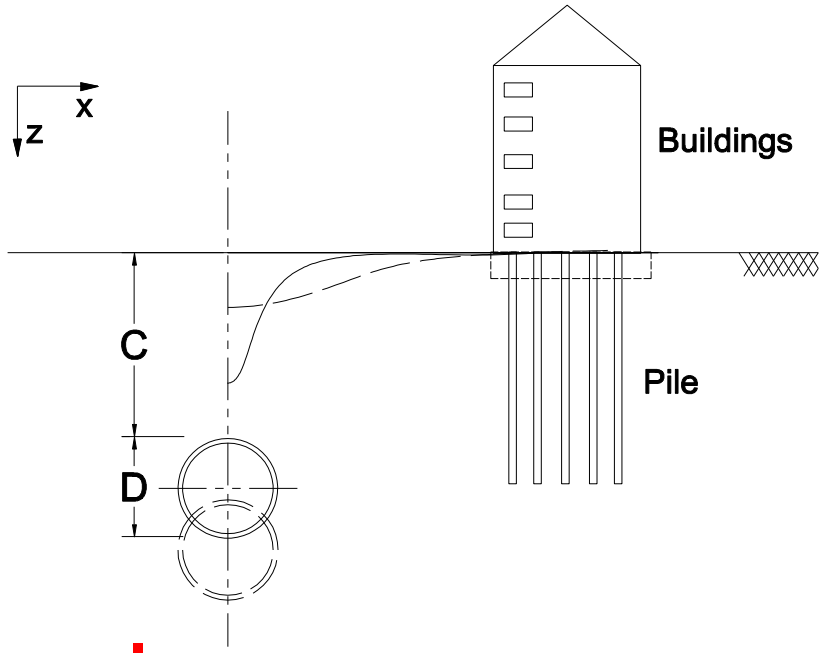
Introduction

- Deep, moderate and shallow tunnels

Deep tunnels

- High cost of construction
- High cost of operation





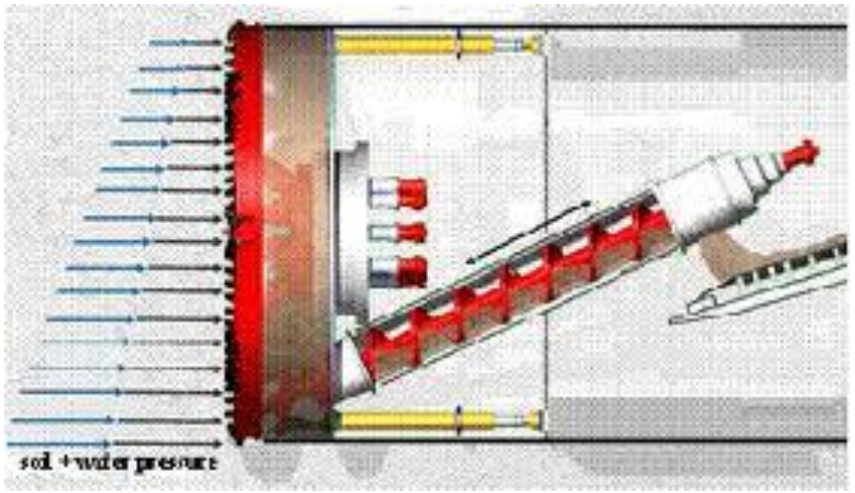
Shallow tunnels

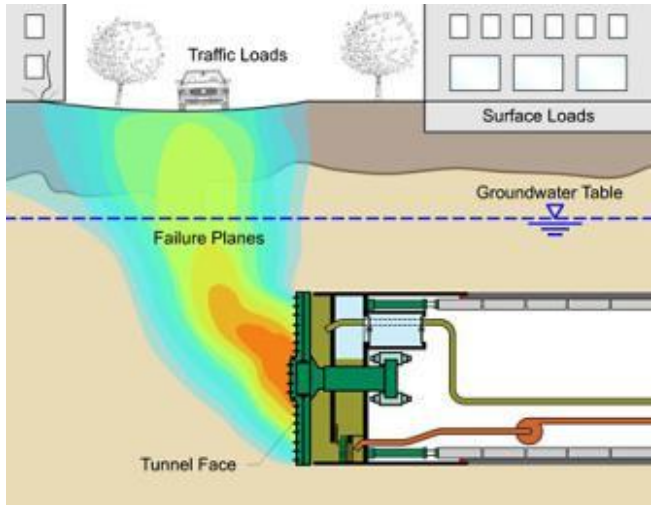
- Reduction of construction cost;
- Low operational cost;
- Shorter travelling time;
- Minimal impact on foundation and existing buildings

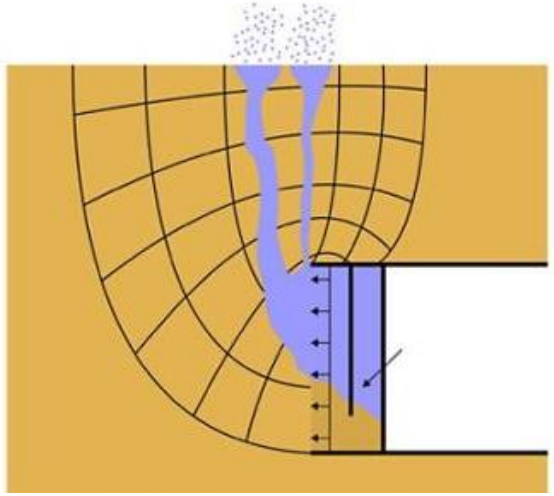
Stability in shallow tunnelling

Support pressure estimate

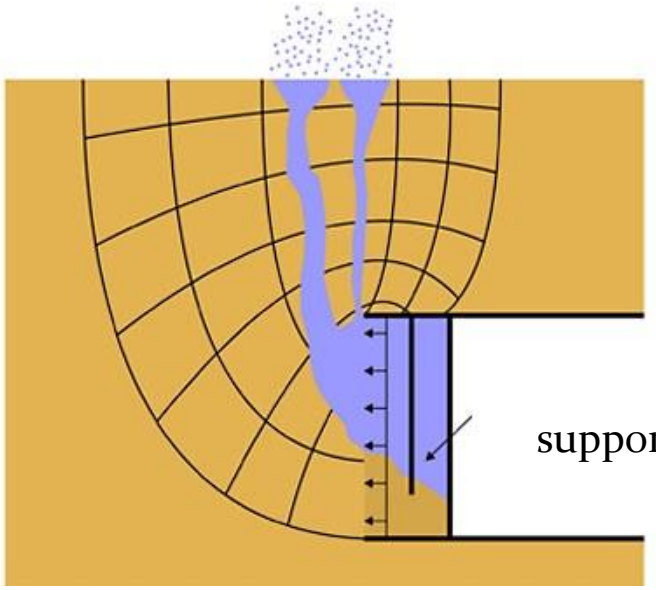
- Wedge model
- Blow-out



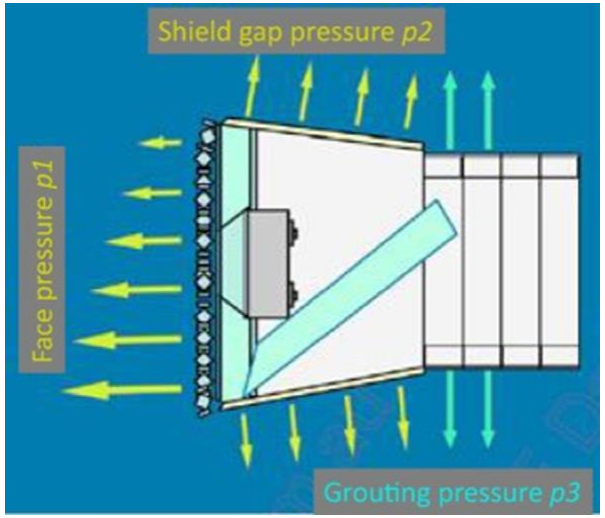




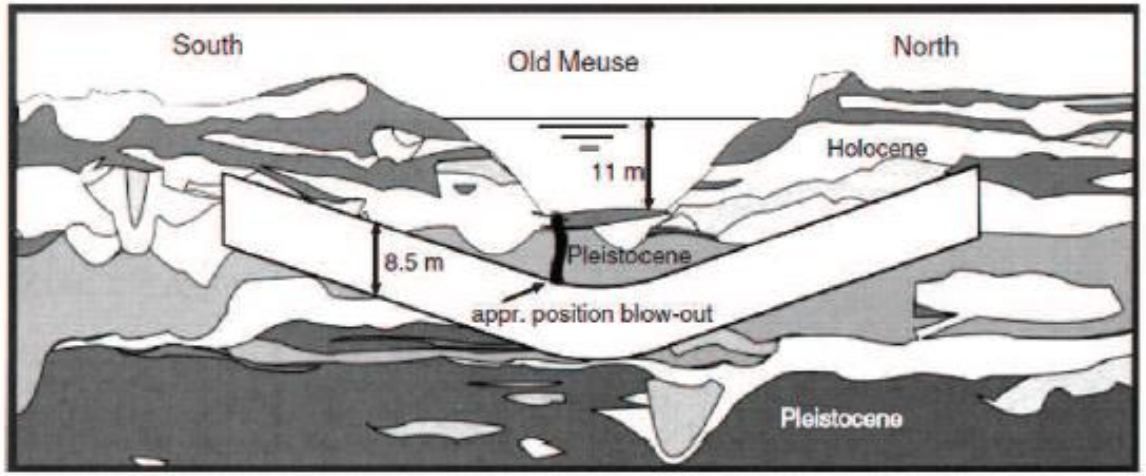
Blow-out



support pressure



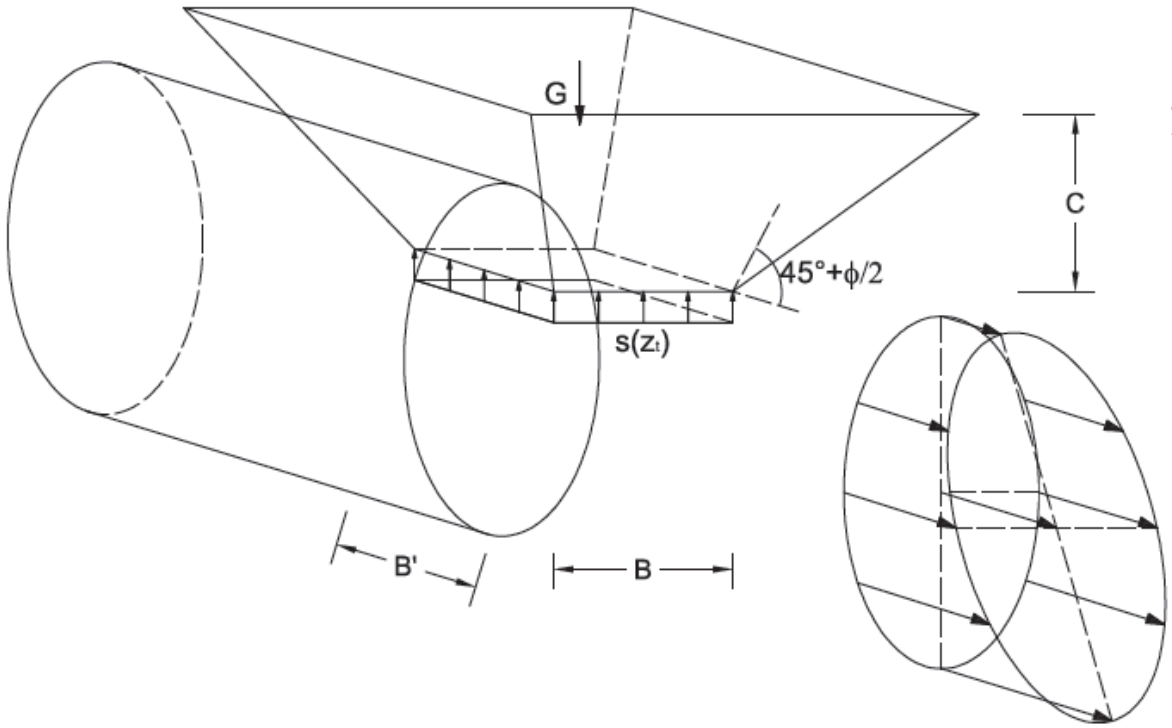
(Source: facesupport.org)



(a) Scheme of the Second Heinenoord Tunnel and the blow-out position

Blow-out models

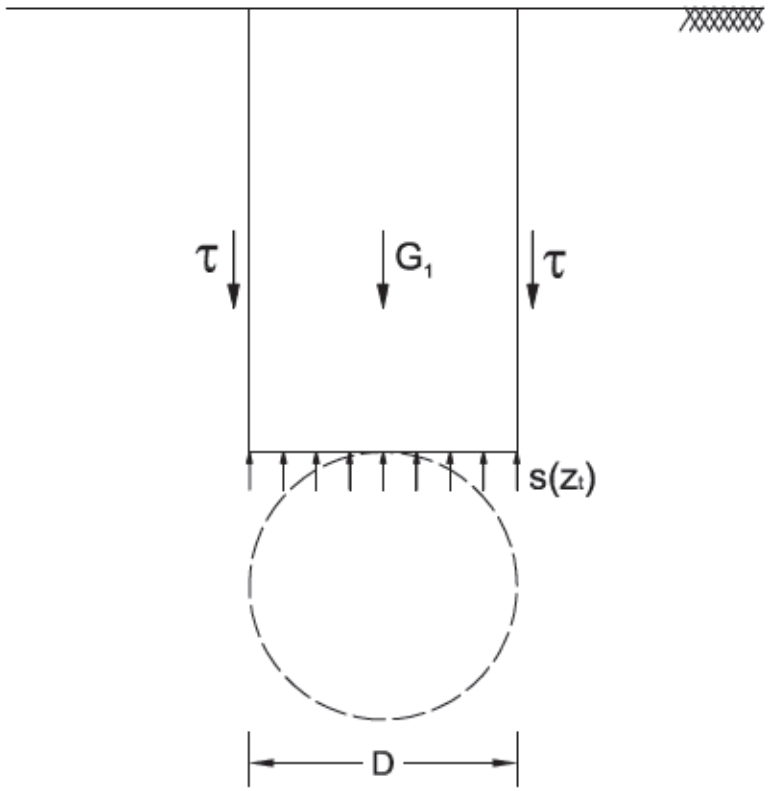
Calculation model of Balthaus for the safety against blow-out (Balthaus, 1991)



Safety indexes against the blow out :

$$\eta = \frac{G}{S} > \eta_1 = \frac{\gamma C\left(B' + C\cot\left(45^o + \varphi/2\right)\right)}{B' s\left(z_t\right)} > \eta_2 = \frac{\gamma C}{s\left(z_t\right)}$$

Blow-out models

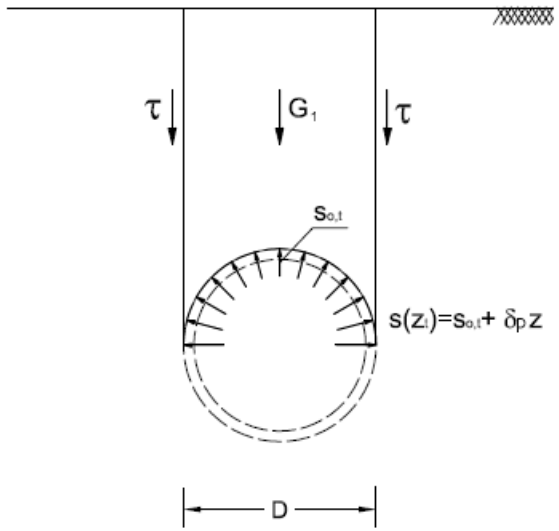


Blow-out model including friction at boundaries (Broere, 2001)

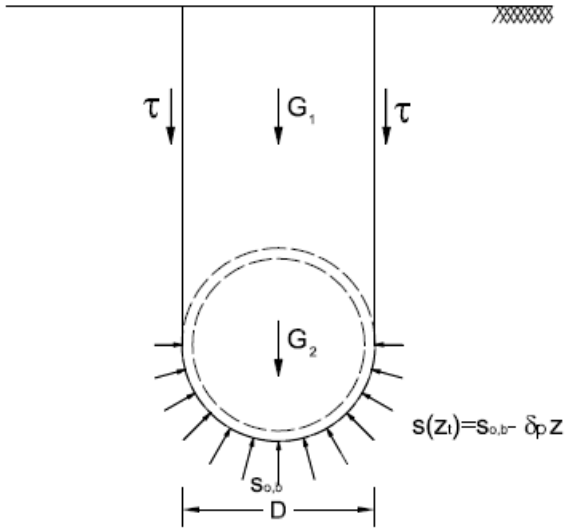
$$s_{max} = C\left(\gamma + \frac{2c + CK_y\gamma' tan\varphi}{D}\right)$$

Blow-out models

Model model including the supporting pressure changes (VU et al., 2015)



(a) upper part



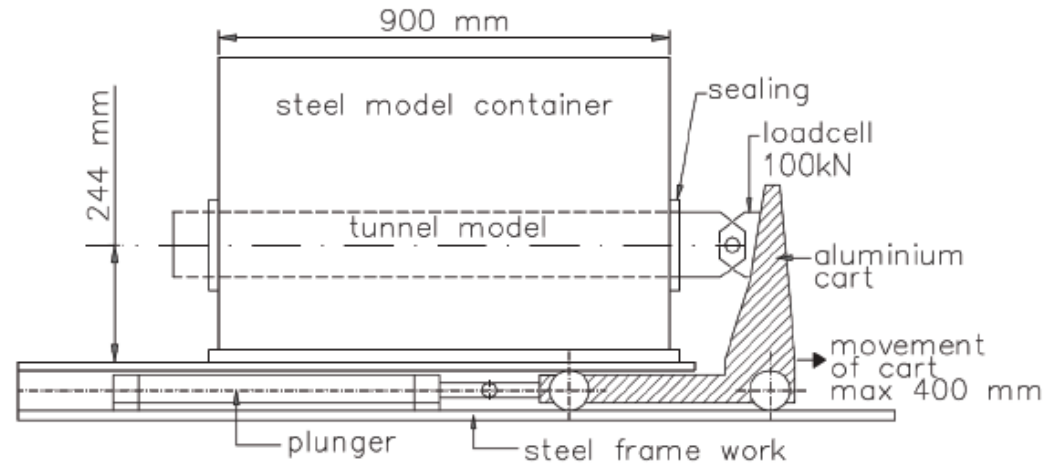
(b) lower part

Linear support pressure with vertical support pressure gradient δp

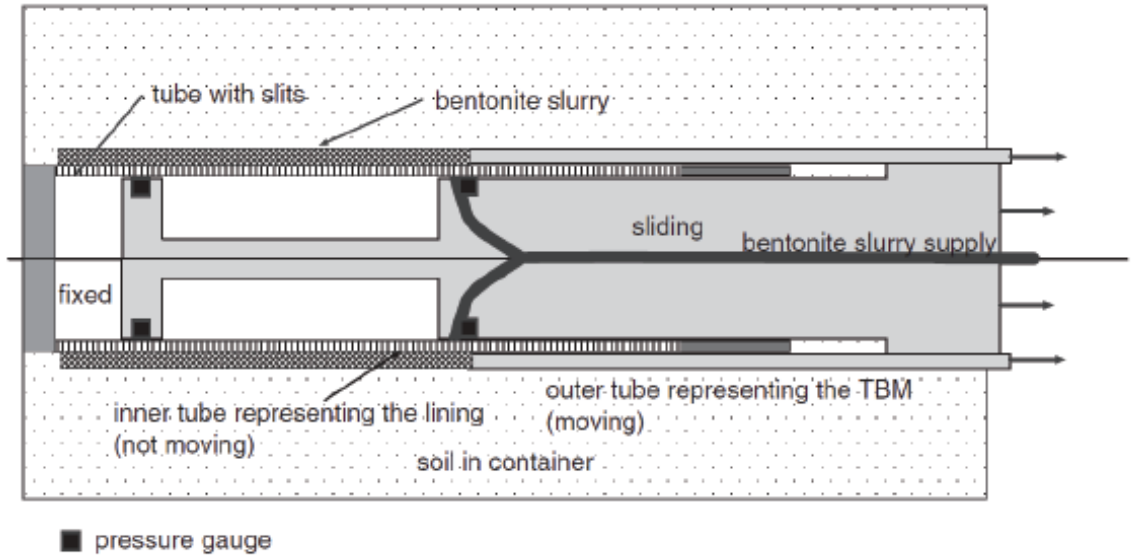
$$s_{t,max} = \left(\frac{C}{D} + \frac{1}{2}\right)^2 2DK_y\gamma' tan\varphi + \left(\frac{C}{D} + \frac{1}{2}\right)(\gamma D + 2c) - \frac{\pi}{8}\gamma D$$

$$s_{b,max} = \left(\frac{C}{D} + \frac{1}{2}\right)^2 2DK_y\gamma' tan\varphi + \left(\frac{C}{D} + \frac{1}{2}\right)(\gamma D + 2c) + \gamma_T \pi d - \frac{\pi}{8}\gamma D$$

Validation with experiments



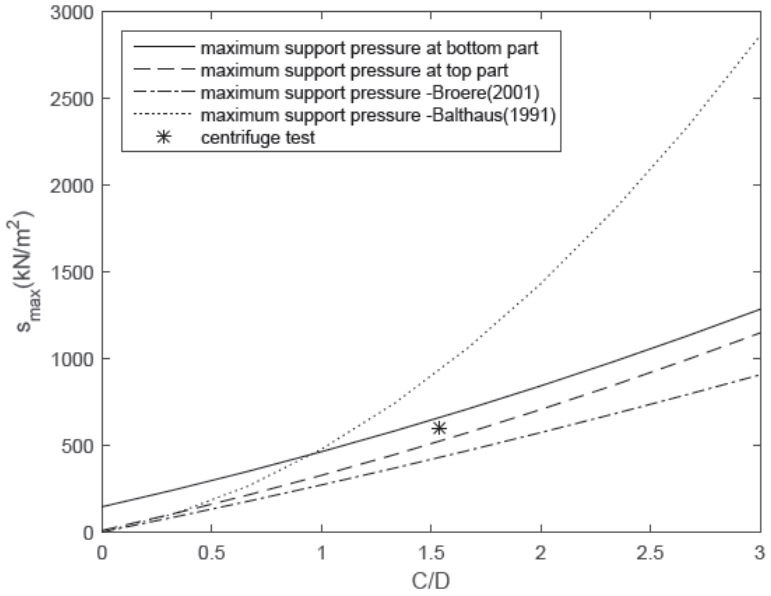
(a) Side view



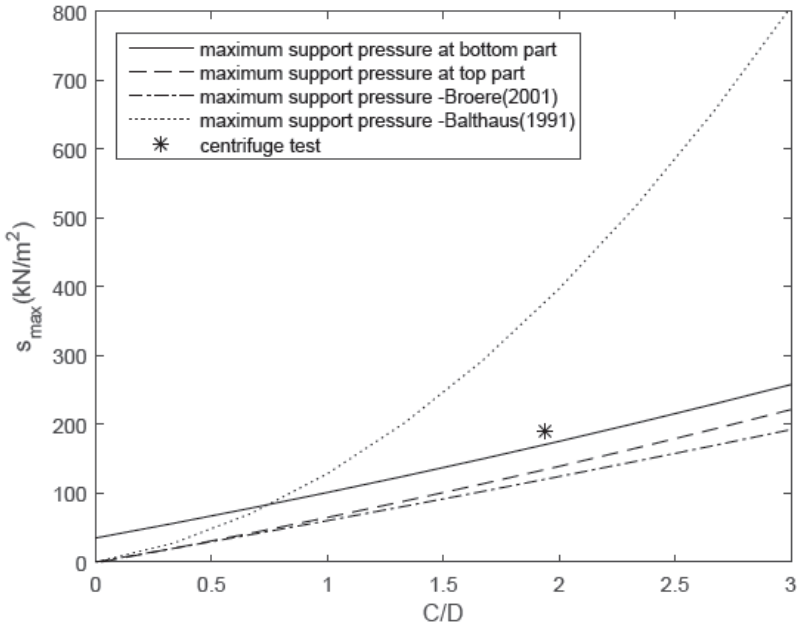
(b) Sketch of the module made to simulate the grouting process

Sketch of centrifuge tests in Bezuijen and Brassinga (2006)

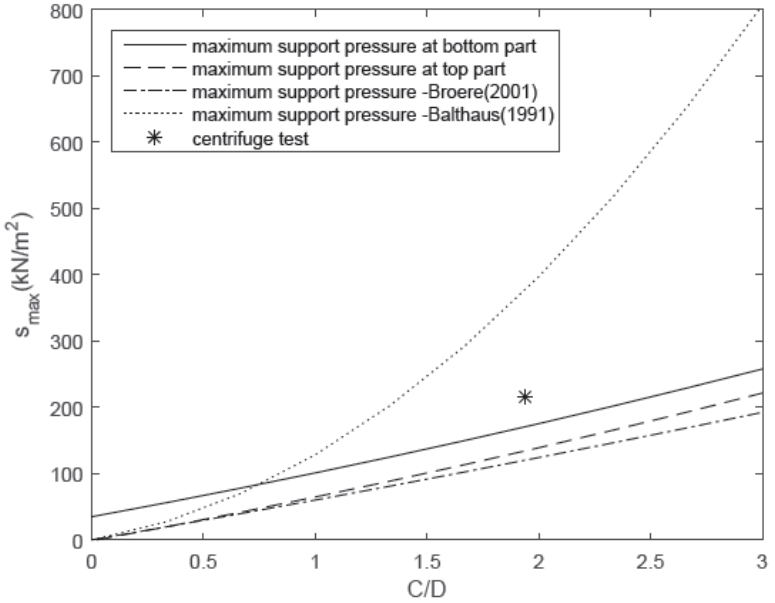
Validation with experiments



(a) with the 1^{st} centrifuge test

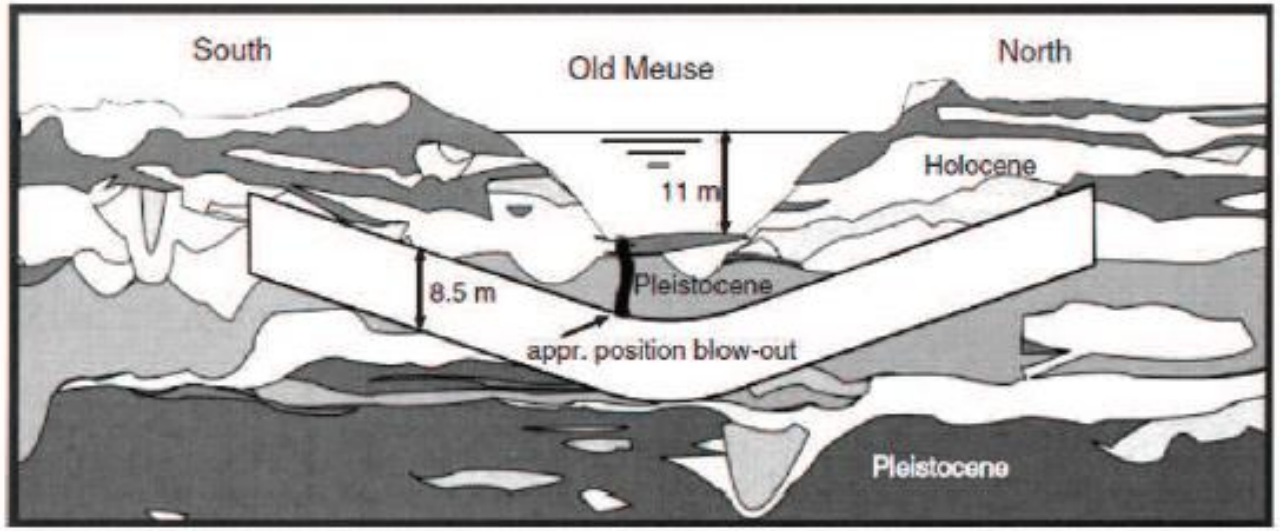


(b) with the 2^{nd} centrifuge test

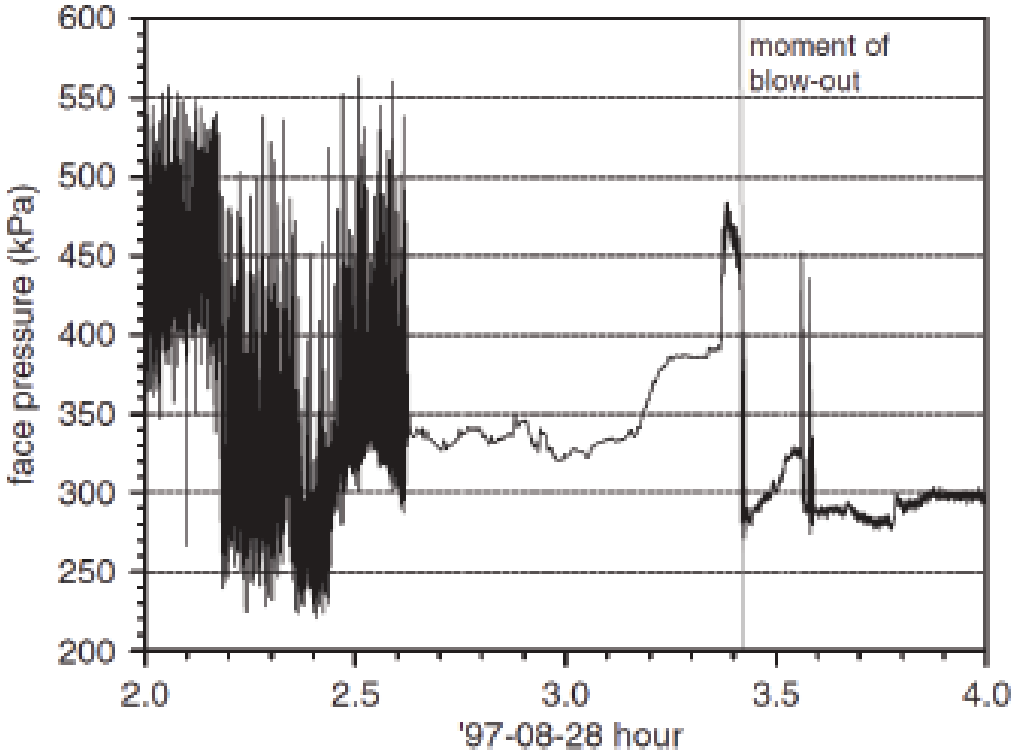


(c) with the 3^{rd} centrifuge test

Validation with case studies



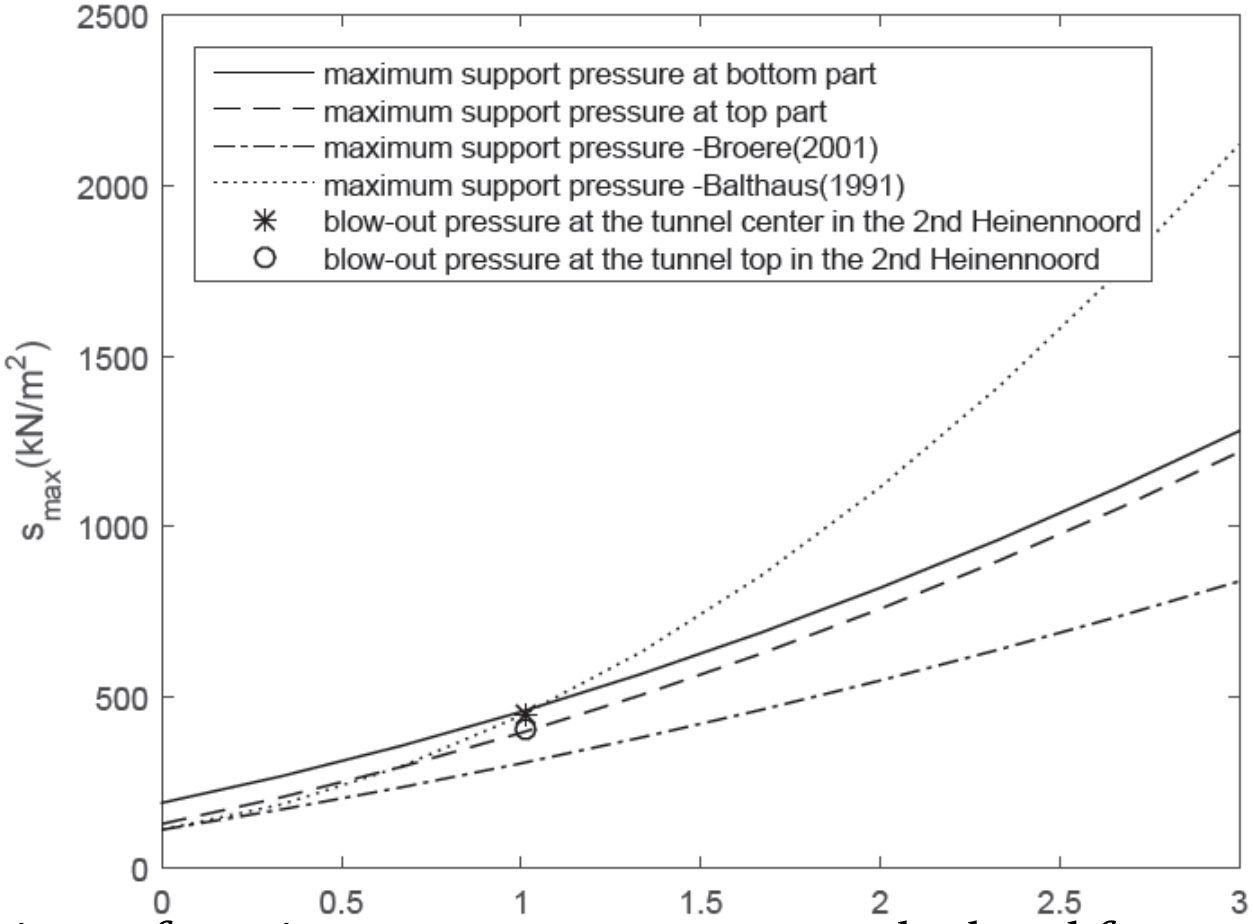
(a) Scheme of the Second Heinenoord Tunnel and the blow-out position



(b) Face support pressure measurement at the tunnel centre during blow-out

Blow-out at the Second Heneinoord Tunnel (Bezuijen and Brassinga, 2006)

Blow-out model



A comparison of maximum support pressures calculated from new blow-out models, Broere's model, Balthaus's model and in the Second Heinenoord Tunnel case

Blowout case study of Hochiminh Metro Line 1

Hochiminh Metro Line 1

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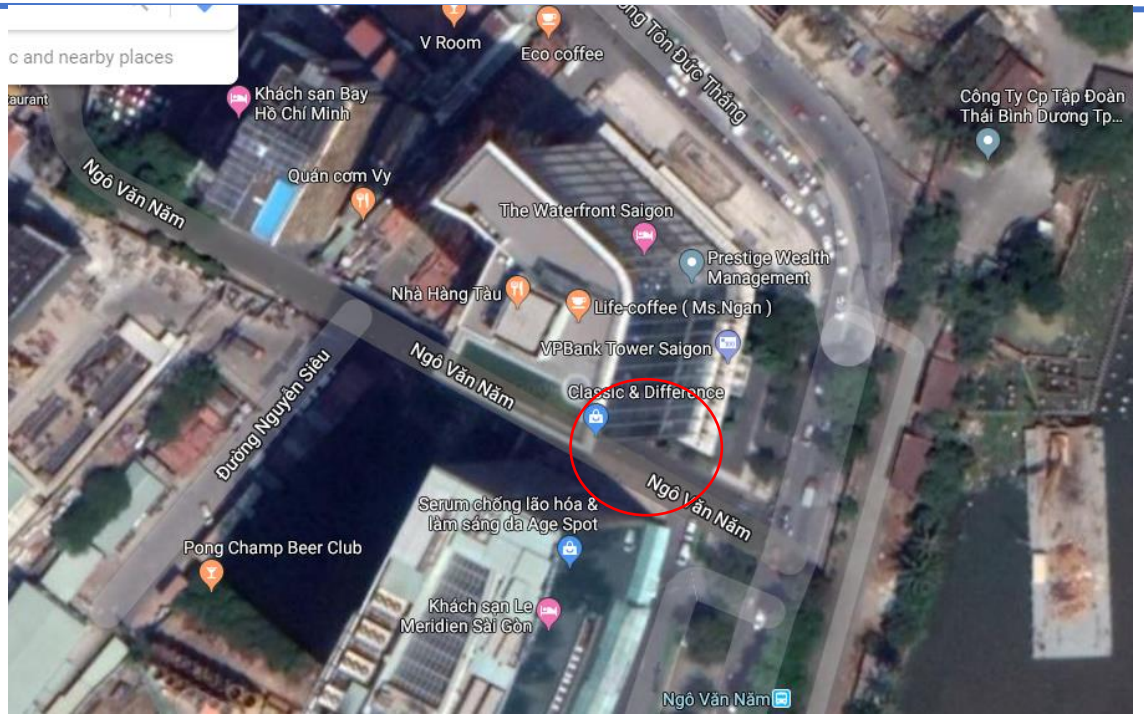

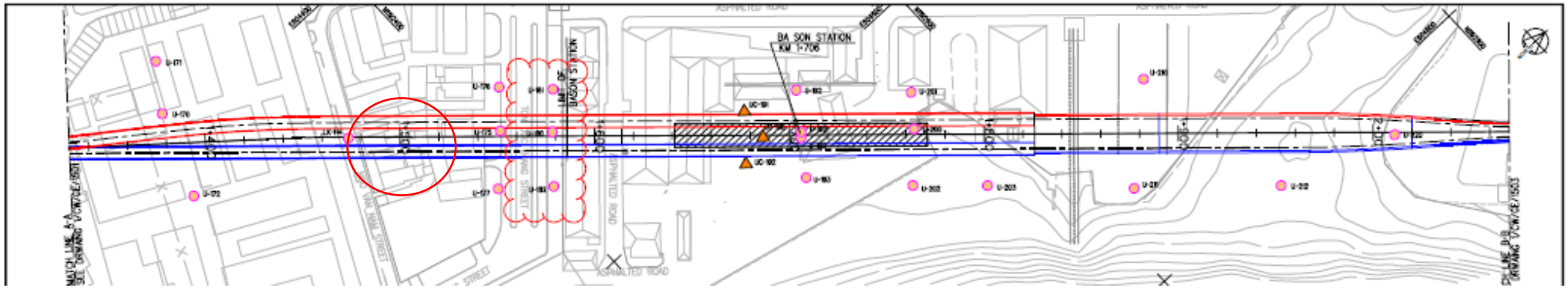

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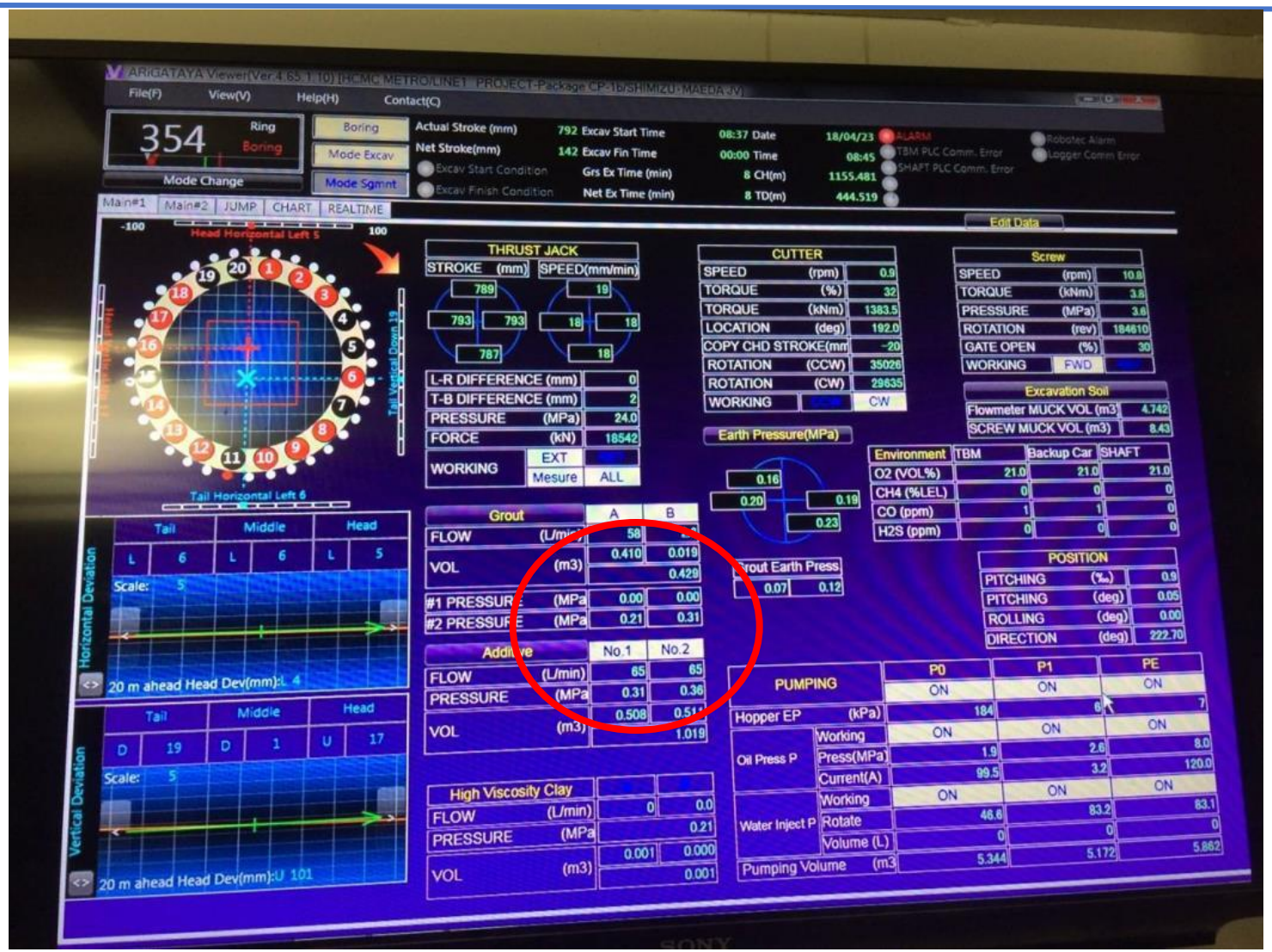
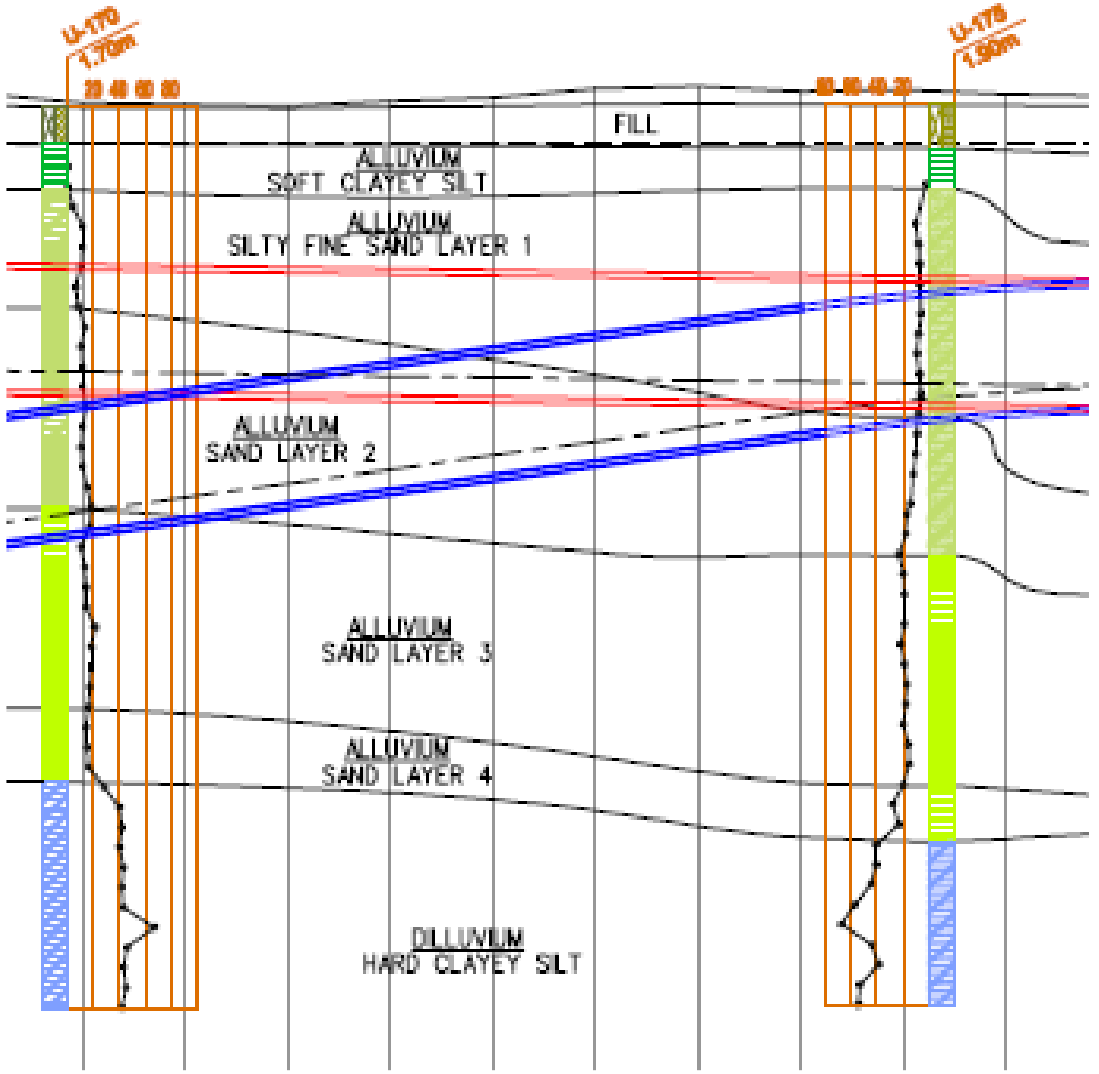


Blowout case study of Hochiminh Metro Line 1

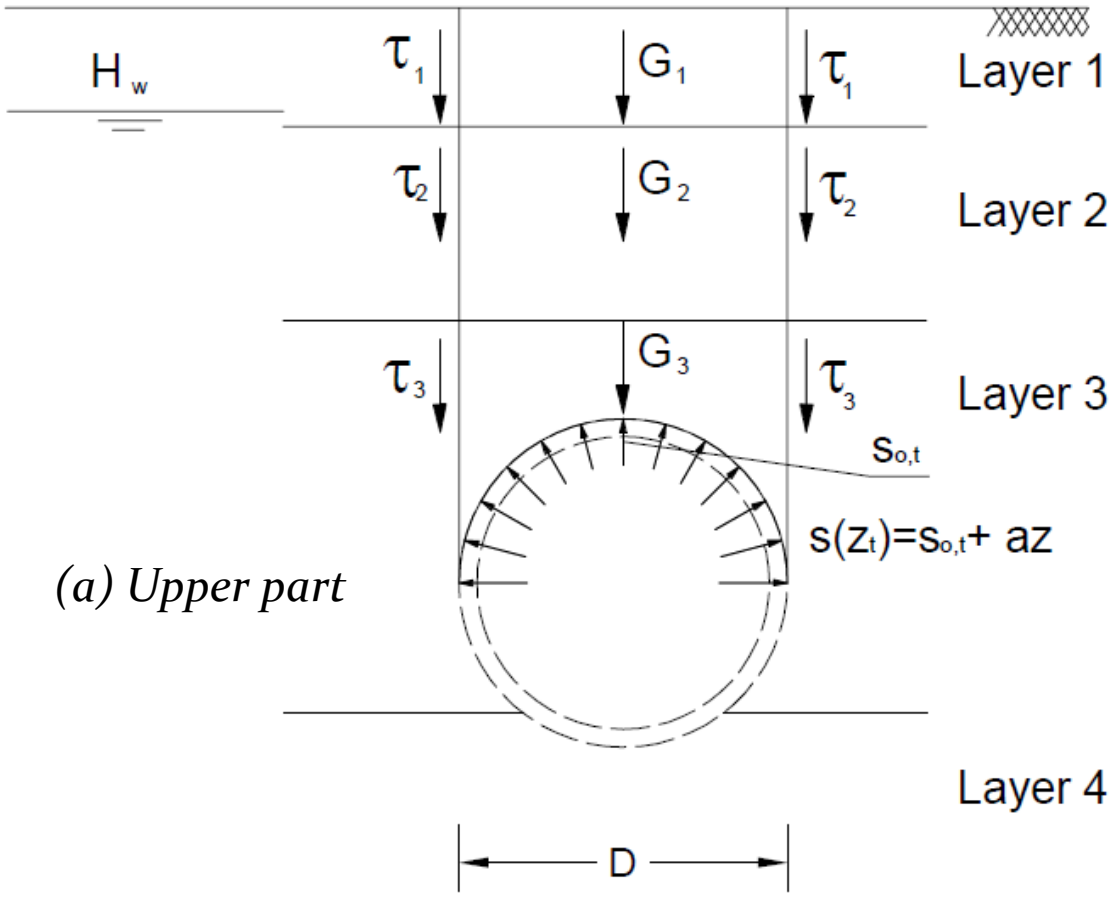
Geo conditions

Table 1. Soil parameters applied in Hochiminh Metro Line 1 Project based on UMRTL1-CP1b-TBMS-CGE-RPT-00073-C report

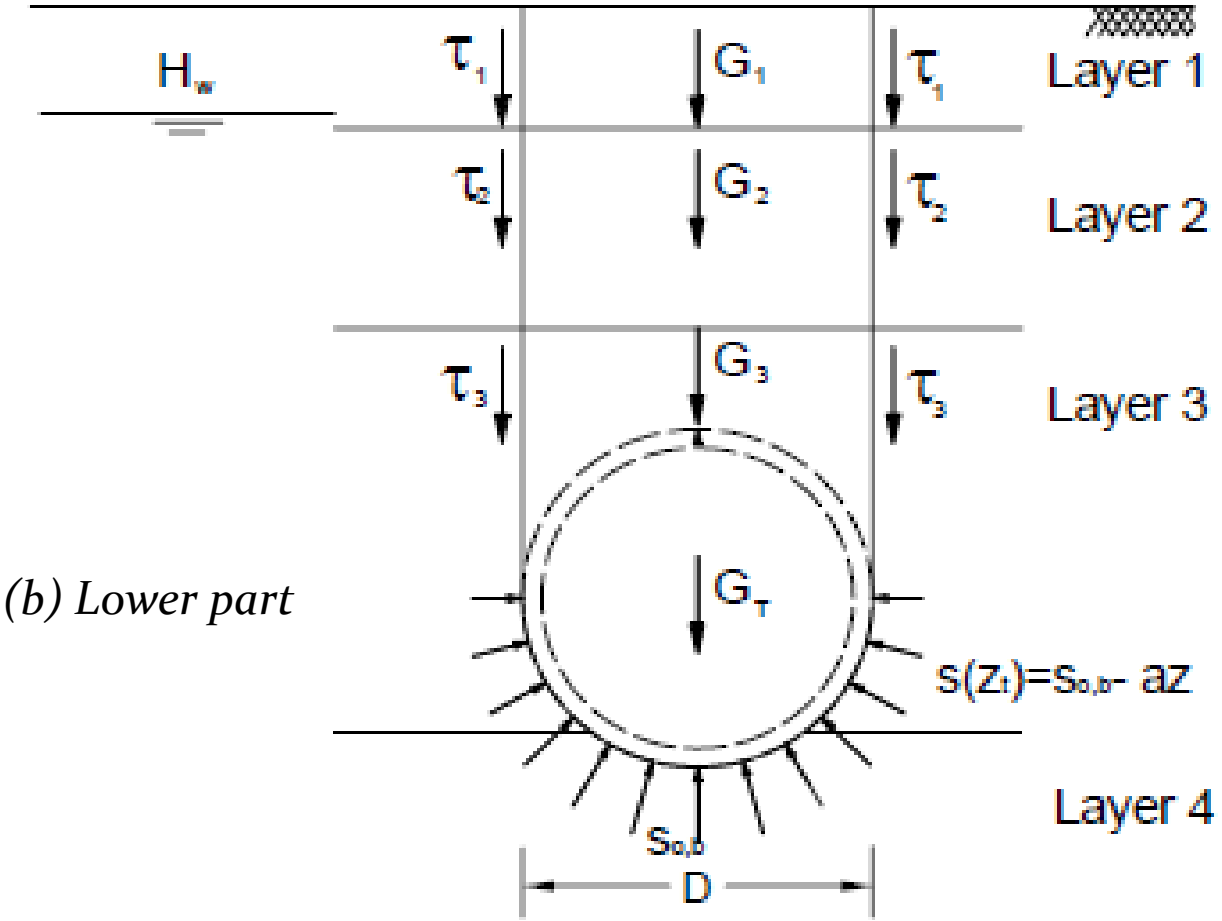
Layer	Description	Level		Weight unit γ (kN/m^3)	Cohe-sion c (kPa)	Friction angle φ (deg.)	Coefficient of Lateral K
		From	To				
1	Fill layer	2.58	0.23	19	10	25	0.6-0.5
2	Alluvium Clay Layer 2	0.23	-1.77	16.5	0	24	0.6-0.5
3	Alluvium Silty Fine Sand Layer 1	-1.77	-13.2	20.5	0	30	0.6-0.5
4	Alluvium Sand Layer 2	-13.2	-17.4	20.5	0	33	0.5



Blowout analysis model for Hochiminh Metro Line 1



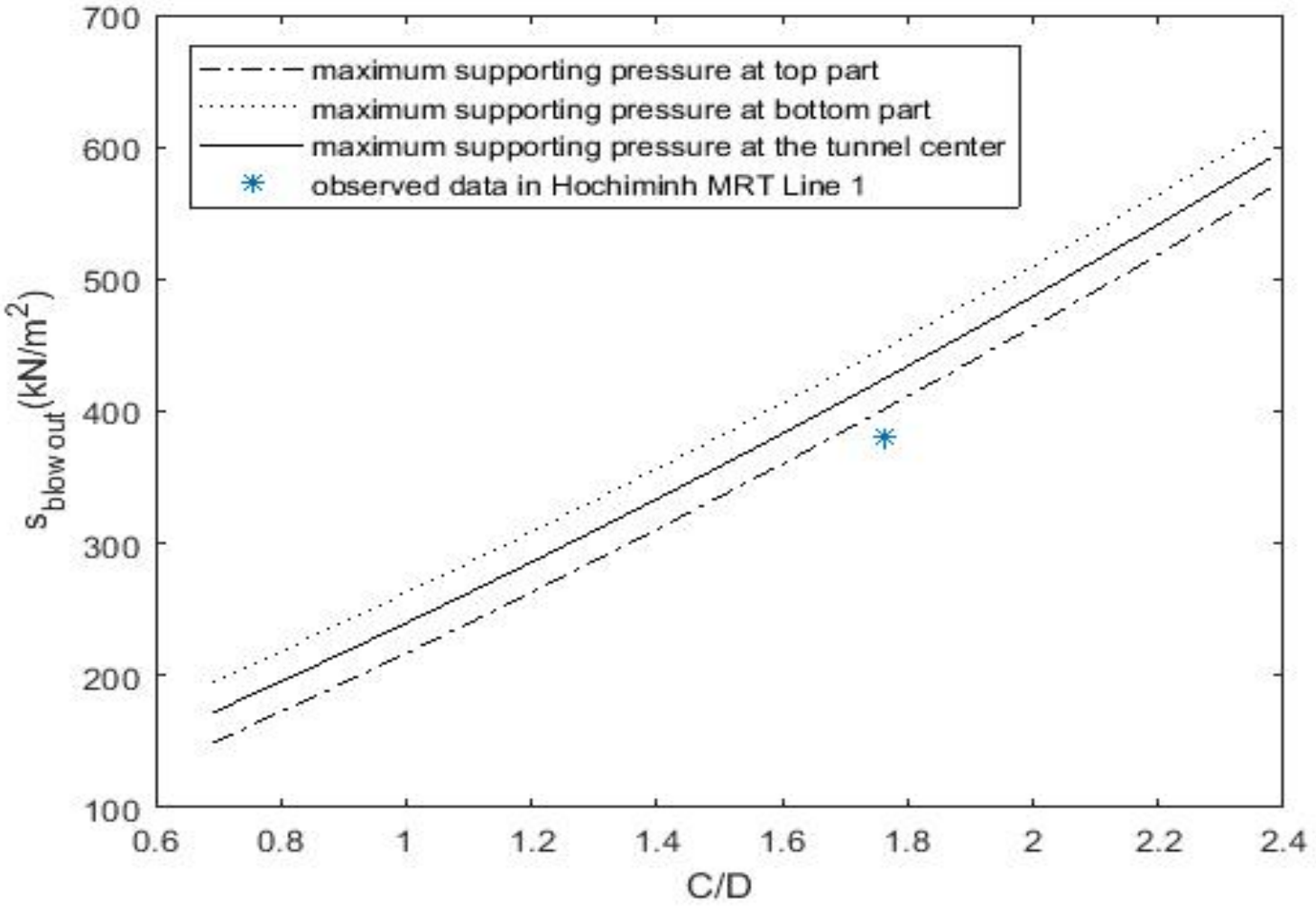
(a) Upper part



(b) Lower part

Blowout analysis model for Hochiminh Metro Line 1

Result:



Conclusions

- Blow-out condition is an essential stability calculation in tunnelling design, especially when shallow tunnelling in soft soils in order to prevent damage on the tunnelling process and existing buildings.

- Blow-out models have been reviewed and compared.

- Validation with the blow-out case study of Hochiminh Metro Line 1 shows a good agreement with the blow-out pressures derived from the linear support pressure blow-out models proposed by Vu et al. (2015).

- The solutions used in the real project of Hochiminh Metro Line 1 show that a careful preparation for risk in tunnelling is very important to have a success tunnelling project.

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Thank you

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