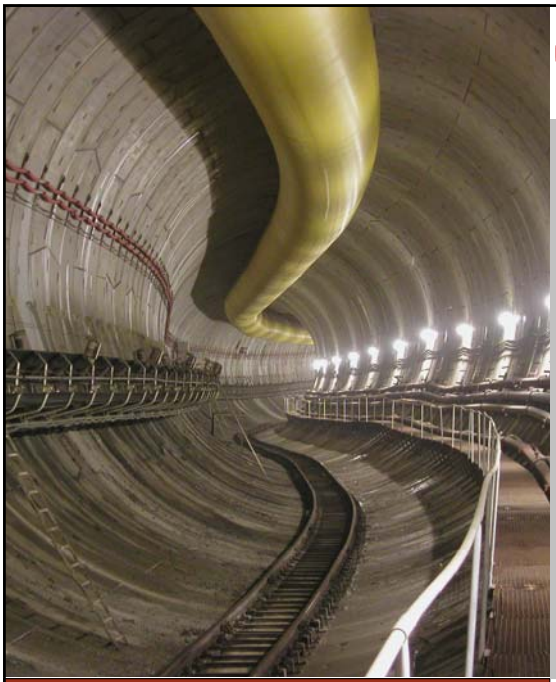


AULA PAYMACOTAS INGENIERIA DE TUNELES

SURFACE SETTLEMENT MINIMIZATION IN SOFT SOIL

WHEN EXCAVATING WITH AN EARTH PRESSURE BALANCE SHIELD

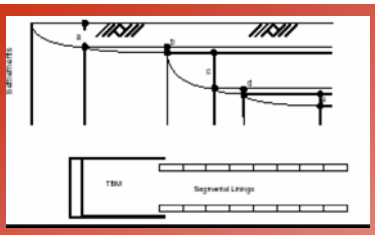
JORNADA TÉCNICA. CAPÍTULO I

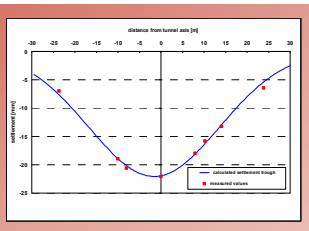
TÚNELES CON EPB: SIMULACIÓN Y CONTROL DE LA TUNELADORA

Escola Tècnica Superior d'Enginyers de Camins, Canals i Ports de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

PAYMACOTAS

VOLUME LOSS AND SETTLEMENTS



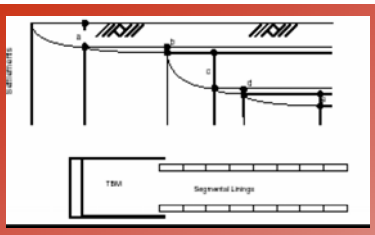


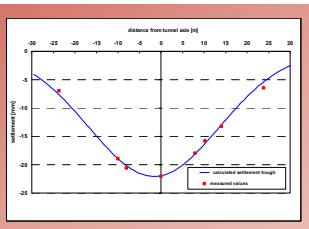
FACE VOLUME LOSS
- deformation of the tunnel face
- intrusion of the surrounding soil towards the excavation chamber

RADIAL VOLUME LOSS
- excavation diameter > shield diameter
- conicity of the shield
- filling of the tail void

OVERALL VOLUME LOSS V_L

MEASURES AGAINST VOLUME LOSSES



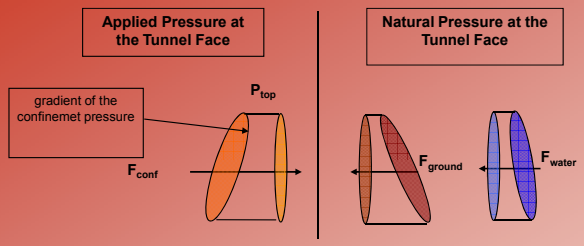


FACE VOLUME LOSS
- application of a suitable confinement pressure at the tunnel face

RADIAL VOLUME LOSS
- shield design
- application of a confinement pressure in in the shield area
- immediate pressure and volume controlled backfilling of the segment rings

Face volume loss

CALCULATION OF THE CONFINEMENT PRESSURE



(a) $F_{conf} \geq \gamma_G \times F_{ground} + \gamma_W \times F_{water}$

(b) $p_{top} \leq \sigma_{ground,V} / \gamma_{sf}$, with p_{top} = confinement pressure at tunnel crown

$\sigma_{ground,V}$ = vertical ground pressure at tunnel crown

Safety coefficients γ_G and γ_W for

- uncertainness in the hydrogeological model
- uncertainness in the geomechanical model
- discontinuities of the TBM-excavation parameters

Safety coefficient γ_{sf} to prevent uplifting of the soil or blowout effects

Face volume loss

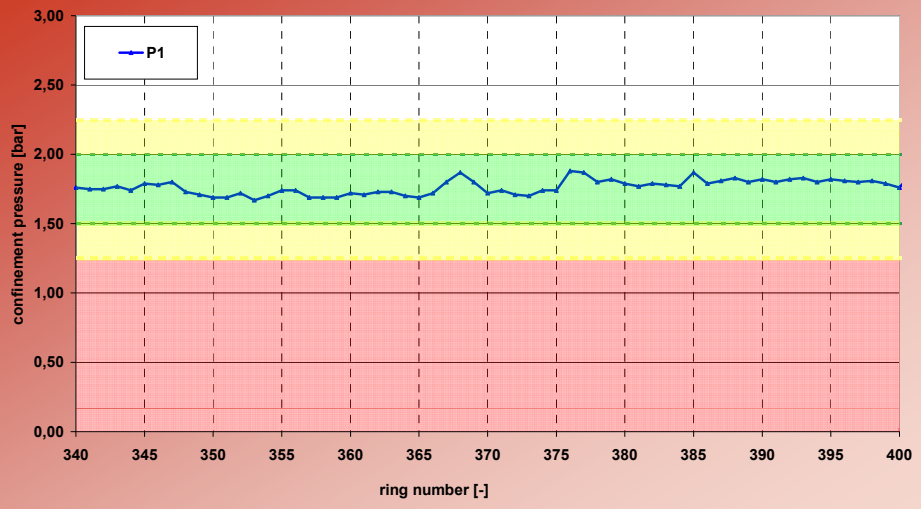
CONTROL OF THE CONFINEMENT PRESSURE

Mechanical face support

- Face opening varies from 20 to 40 %
- At least 60% of the cutting wheel face is contributing to the support

Face volume loss

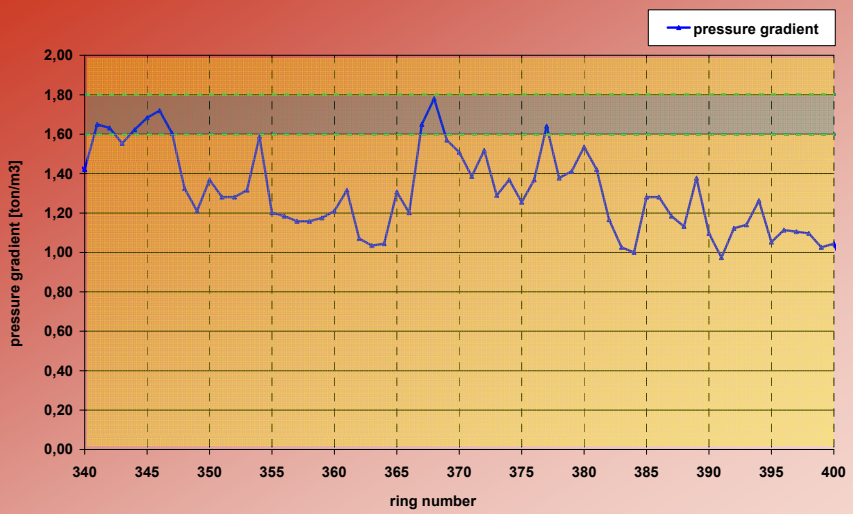
CONTROL OF THE CONFINEMENT PRESSURE



SURFACE SETTLEMENT MINIMIZATION IN SOFT SOIL
WHEN EXCAVATING WITH AN EARTH PRESSURE BALANCE SHIELD

Face volume loss

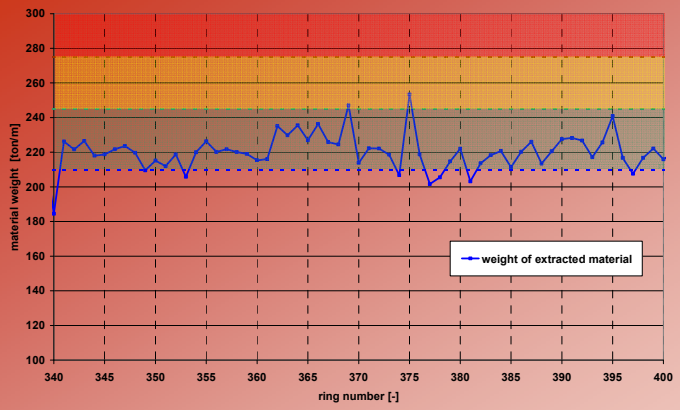
CONTROL OF THE MATERIAL DENSITY



SURFACE SETTLEMENT MINIMIZATION IN SOFT SOIL
WHEN EXCAVATING WITH AN EARTH PRESSURE BALANCE SHIELD

Face volume loss

WEIGHT CONTROL OF THE EXTRACTED MATERIAL

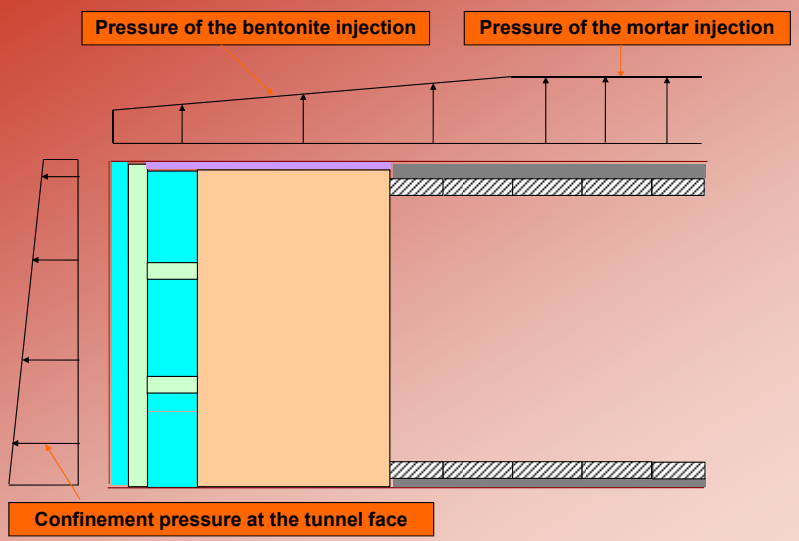


V_L = 1% → 2.5 ton/m for 12 m diameter shield

- the weight control could be an important parameter to verify the calculation of the confinement pressure
- actualy the precision of the available weighting units are not sufficient
- system must be improved for future applications

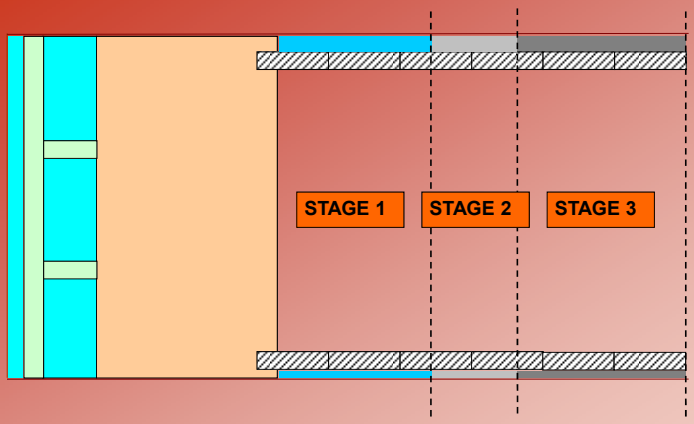
Radial volume loss

BENTONITE INJECTION THROUGH THE SHIELD



Radial volume loss

FILLING OF THE ANNULAR GAP

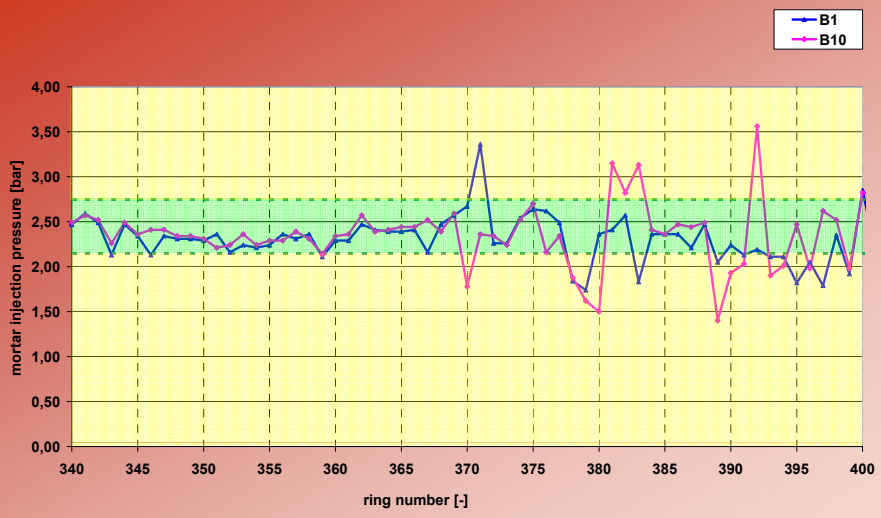


Pressure and volume controlled backfilling

- The injection pressure in the tunnel crown should correspond to the vertical ground and water pressure

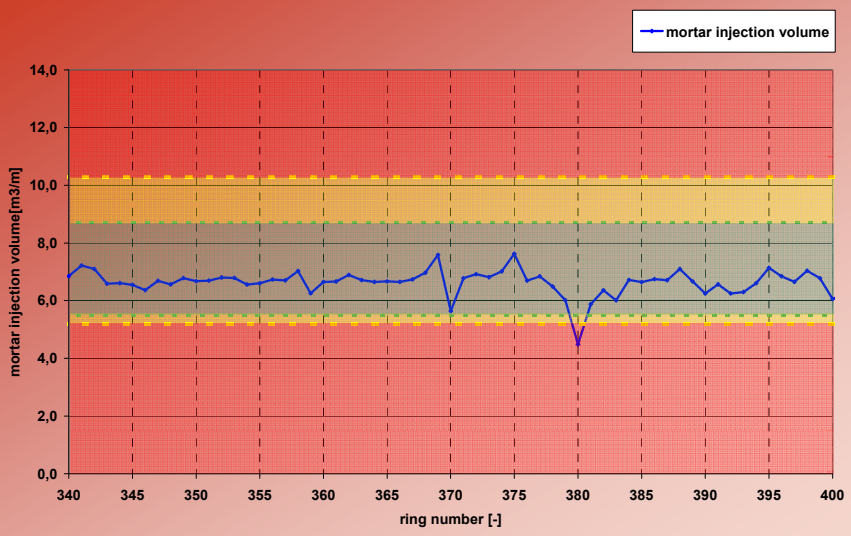
Radial volume loss

CONTROL OF THE MORTAR INJECTION PRESSURE



Radial volume loss

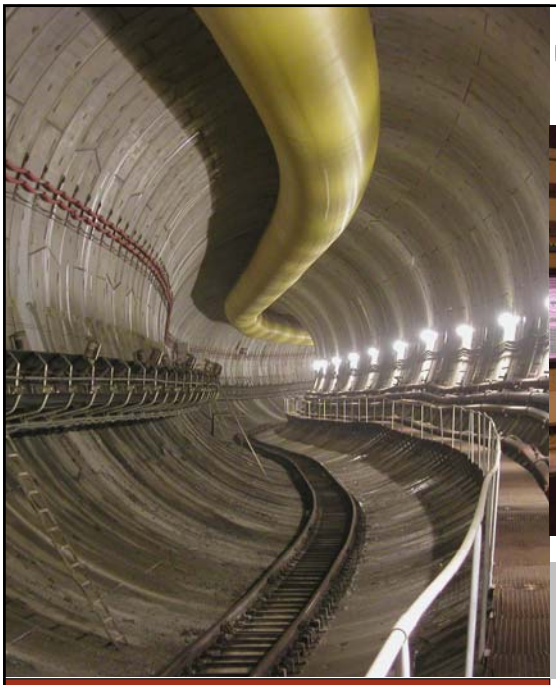
CONTROL OF THE MORTAR INJECTION VOLUME



Control of volume losses

SITE PROTOCOL FOR CONTROLLING TBM PARAMETERS

EPB SHIELD CONTROL PARAMETERS - P.K. 2+400 to P.K. 2+600			
PARAMETER	REFERENCE	WARNING	ALERT
confinement pressure in tunnel crown	1,75 bar *per ring and if t>2h every 2h*	<1,5 bar >2,0 bar *per ring and if t>2h every 2h*	<1,3 bar >2,3 bar *during 15 minutes*
pressure gradient	1,7 t/m³ *per ring and if t>2h every 2h*	<1,6 t/m³ >1,8 t/m³ *per ring and if t>2h every 2h*	
confinement pressure at tunnel axis	2,45 bar *per ring and if t>2h every 2h*		<2,0 bar >3,0 bar *during 15 minutes*
mortar injection pressure lines B1 and B10	2,3 bar *per ring*	<1,2 bar >2,8 bar *per ring*	Depending on the injection volume
mortar injection volume	6,5 m³/ml *per ring*	<5,5 m³/ml >8,7 m³/ml *per ring*	< 5,2 m³/ml >10,3 m³/ml *per ring*
FIR	min 25		
FER	min 20		
max. penetration	60 mm/rev *per ring*	< 20 mm/rev *per ring*	< 3 mm/rev *during 15 minutes*
weight of extracted material		> 245 ton/ml *per ring*	> 275 ton/ml *per ring*



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¡THANK YOU FOR YOUR ATTENTION!

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