



# 16<sup>TH</sup> AUSTRALASIAN TUNNELLING CONFERENCE 2017

30 OCT - 1 NOV 2017  
THE STAR SYDNEY

**CHALLENGING UNDERGROUND  
SPACE: BIGGER, BETTER, MORE**

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# Günther VOLKMANN

# Optimization Potential Regarding Safety, Material, and Installation Time for Pipe Umbrella Installation Methods

## Classification

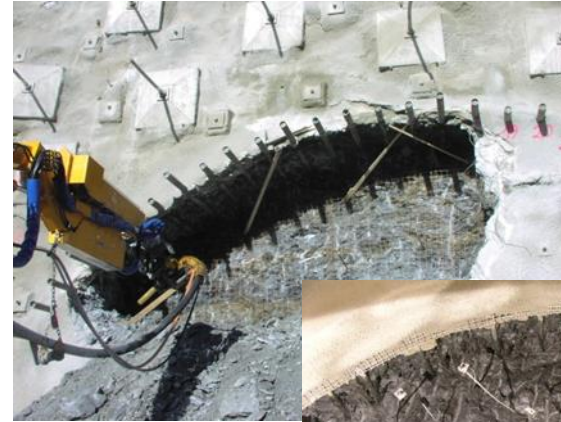
- Pre-support
- Umbrella method (Muraki,1997)

Pipes are installed prior to the excavation

- Outer diameter 70-200mm
- Wall thickness 5-15mm

Application area: weak ground

AU: Pipe Umbrella = Canopy Tube



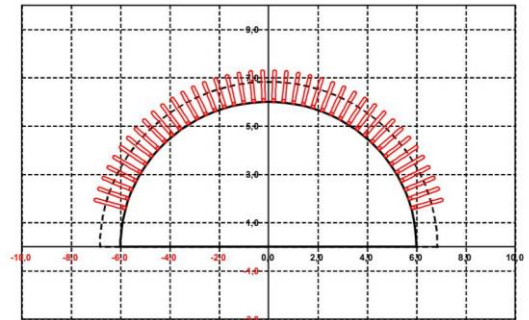
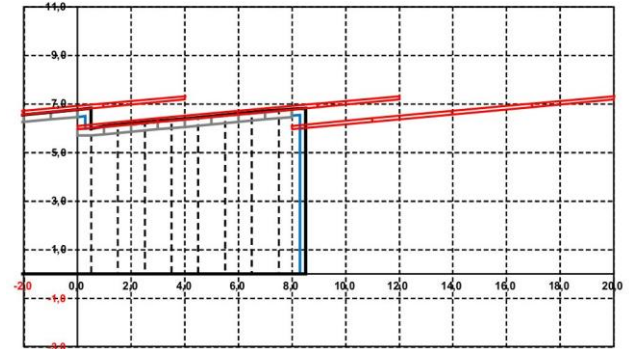
# Exemplary Pipe Umbrella

12 m diameter tunnel

- 12 m long pipe umbrella
- 40 pipes
- Overlap > 3.5 m

Variations / Optimizations:

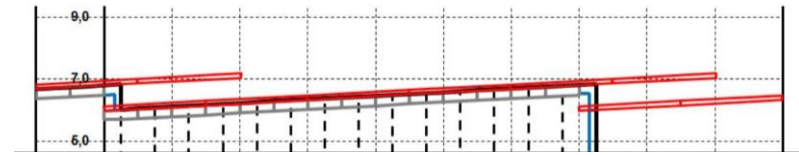
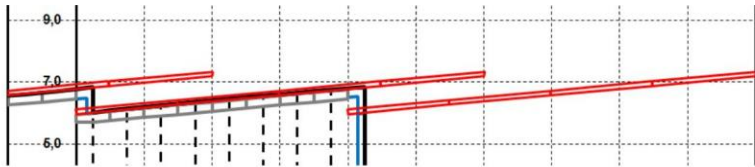
- Change from 12 m to 18 m in length
- Change from threaded to squeezed connections





# Material consumption for pipe umbrellas

Pipe umbrella length	Excavation length	Axial pipe distance	Maximum axial distance	Pipes installed	Pipe per rm tunnel	Over-excavation	Over-excavation per rm tunnel
12 m	8 m	400 mm	456 mm	480 m	60.0	70.4 m <sup>3</sup>	8.8 m <sup>3</sup>
15 m	11 m			600 m	54.5	95.3 m <sup>3</sup>	8.7 m <sup>3</sup>
18 m	14 m			720 m	51.4	120.1 m <sup>3</sup>	8.6 m <sup>3</sup>



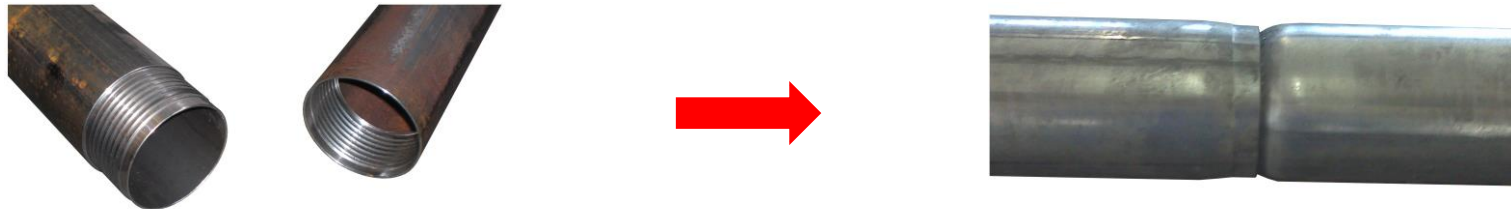
# Material: Thread vs. Squeezed Connection

Pipe type	Coupling type	W [cm <sup>3</sup> ]	W [%]	I [cm <sup>4</sup> ]	I [%]	M <sub>el</sub> * [kNm]	M <sub>el</sub> [%]	M <sub>pl</sub> * [kNm]	Weight [kg/m]
139.7x6.3	squeezed	58.4	100	344.0	100	<b>20.7</b>	100	>40.0	20.7
	none (tube)	84.3	144	588.6	171	29.9	144	n/a	
139.7x10.0	cut thread	53.6	92	345.3	100	<b>19.0</b>	92	n/a	32.0
	none (tube)	123.4	211	861.9	250	43.8	212	n/a	

\* Values must be proven by the manufacturer with certificates.

M<sub>el</sub> ... Maximum bending moment [kNm] in the elastic material range

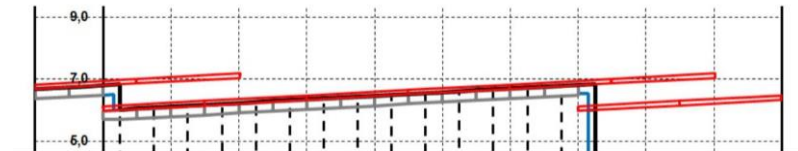
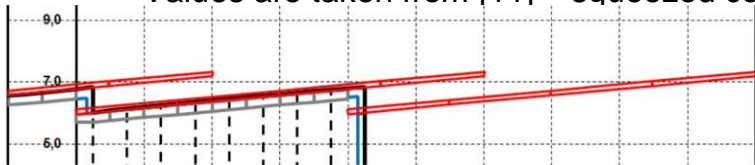
M<sub>pl</sub> ... Maximum bending moment [kNm] when using plastic reserves of the steel material



# Installation Time: 12 m vs. 15 m vs. 18m

Type	Excavation length	Pipes installed	Pipes per m tunnel	Installation time per m tunnel *	No of couplings	Coupling per m tunnel
	[m]	[m]	[m]	[min]	[-]	[-]
12 m	8	480	60.0	150	120	15.0
15 m	11	600	54.5	136	160	14.5
18 m	14	720	51.4	128	200	14.3

\* Values are taken from [11] – squeezed connection only



# Connection Time: Thread vs. Squeezed

Type	No. of connections per tunnel meter	Single connecting time	Connecting time	Single delay time *	No. of difficult connections	Delay time	Total connection time
	<b>[-]</b>	<b>[min]</b>	<b>[min]</b>	<b>[min]</b>	<b>[%]</b>	<b>[min]</b>	<b>[min]</b>
Standard thread	15	3.5	52.5	10	5	7.5	60
Squeezed coupling		1.5	22.5	-	0	0	22.5
<b>Time savings</b>			<b>30</b>			<b>7.5</b>	<b>37.5</b>

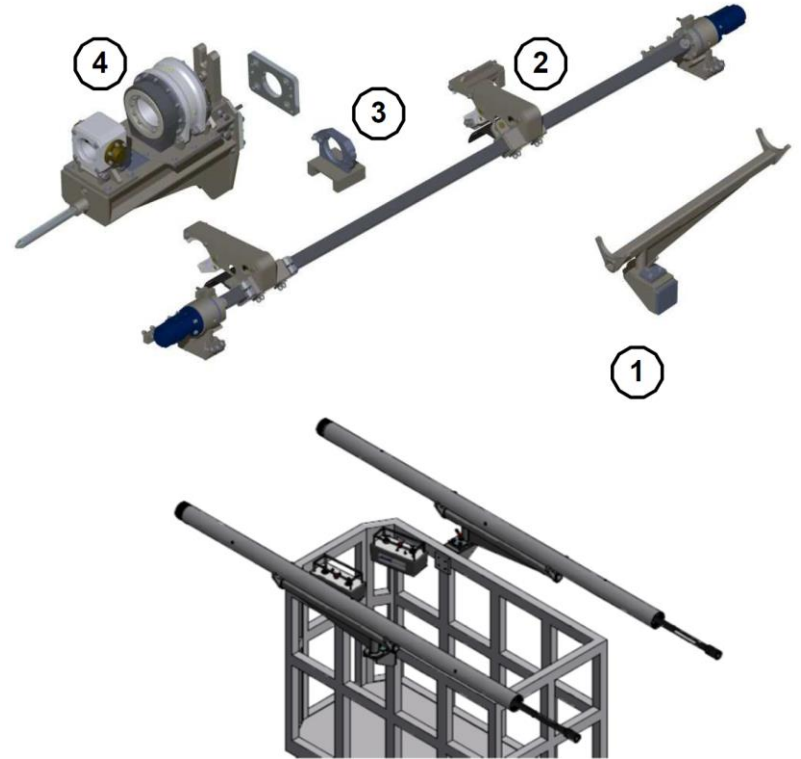
\* Experience: 5% difficult connections (outliers) which require additional handling time



# AT – Automation Unit

- (1) Pipe deposition on basket
- (2) Loading device with hydraulic arms
- (3) Central guide
- (4) Threading or Squeezing Unit

Can be mounted on all common  
drilling machinery





# Comparison: Manual vs. Automated

Installation step	Manual installation	Automated installation
<b>Pipe is loaded onto the basket (mostly tube deposits)</b>	Manually, workers on the ground	
<b>Drill steel is loaded on the basket into the pipe</b>	Manually, workers on the ground	
<b>Disconnection of drill steel</b>	Manually with wrench	Remote controlled with hydraulically controlled wrench
<b>Pipe is fed to loading device</b>	n.a.	By moving the basket plus remote control
<b>Pipe is fed to drill arm</b>	Manually lifted from basket to drill arm	Remote controlled from hydraulically controlled arms to drill arm
<b>Re-connection of drill steel</b>	Manually	Remote controlled
<b>Connection of steel pipes</b>	Manually with aid of chain pipe wrench	Remote controlled with threading unit or squeezing unit
<b>Drilling</b>	Mechanized by drilling machine	

# Summary

Simple Changes in the way of installing pipe umbrella systems results in significant advantages for an exemplary 100m long pipe umbrella supported tunnel (pipe dimension 139.7x6.3).

- 12 m => 18 m: **17.8 tons** of steel tube savings.
- Thread => squeezed connection: **58 tons** of steel tube savings.
- 12 m => 18 m: **36.7 hours** less installation time.
- Tread => squeezed connection: **62.5 hours** less installation time.
- **Significantly lower risk of injuries or damages** when using AT - Threading Units or AT - Squeezing Units to uncouple drill steel or elongate steel tubes.
- **Less fatigue and exhaustion, higher efficiency, and less risk for injuries** by using an adequate grade of mechanization or even automation.