TBM: The Birth, Influences .... and the Future

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``Norwegian tunnel builders are the world's best – a myth?``
by Arild Palmström, MSc, PhD., Rockmass AS 2014

``Maybe in hard rock, but in soft or mixed soil...?``
Martin Knights FREng 2019
Leading the world

Stad Ship Tunnel – construction of the world’s first ship tunnel may commence in 2018. With a section of 1620 m² and length of 1.7 km, it will offer safe passage through a notoriously exposed piece of coast with many ship accidents.

Solbakk Tunnel – as a part of the Ryfast connection- the world’s longest subsea road tunnel will be 14.3 km long when completed in 2018 the world’s deepest road tunnel 2018.

The Helgeland Tunnel, the is being planned to descend 396 m below sea level – more than 100 m below any other road tunnel in the world today. When it opens for traffic in 2023, Rogfast Road Link in Rogaland will become the world’s longest sub-sea road tunnel at 27 km, and among the world’s deepest at 390 m.

The Follo double-tube Railway tunnel will be Norway’s longest rail tunnel when completed in 2021. Most of the 20 km tunnels will be excavated by TBMs.
Contents

• Introduction
• 1 Birth & evolution
• 2 Influences on the tunnel industry
• 3 Predictions
• 4 What can owners do?
TBM`s = Family`s and Dynasty`s

But what does TBM mean?
The British Method?
The Boris (Johnson) Method

Brexit negotiations enter the ‘tunnel’
TBM

- The Brunel Method
- Innovation!!
- Mother nature
TBM = The Brunel Method

Sir Marc Brunel - Father & Inventor of the first tunnel shield

Isambard-son & his first job

The Thames Tunnel
1.0 The birth of the TBM & evolution

Bertha TBM Seattle 2015
History of The River Thames  50,000BC - 2019
A River to Cross

Solution?
A tunnel was the only way to get cargo across the river without stopping the tall masted ships, but no-one had tunnelled under a river before.
Brunel found the inspiration for his tunnelling shield from *Teredo navalis* which has its head protected by a hard shell whilst it bores through ships' timbers. Brunel's invention and patent in 1818.

The ship worm tunnel is circular in cross section and is lined with calcareous material extruded by the mollusc. It can be up to 60 cm (24 in) long and 1 cm (0.4 in) in diameter.
Client instructions for Marc Brunel!

- Cross under the river
- Large enough for horse drawn carriages to pass
- Low cover to tunnel
- Soft gaseous ground
- River Thames was a toxic open sewer!
- Never been done before
- Investors had `tight budget``
- Do it ASAP!
Early idea`s

Evolution of early innovative thoughts
Patent 1818
Brunel`s proposals were illustrated using the `Powerpoint` of the 19th Century!
Marc Brunel`s solution
The world`s first tunnelling shield
St Clair Rail Tunnel  The first underwater rail tunnel in North America was opened by the St. Clair Tunnel Company in 1891.
Evolution of shields and TBM

OVER 200 YEARS of Tunnelling under London

Contributed to the growth of London
2.0 Rock TBM`s

- Early attempts 19th Century
- The English French Channel Tunnel
- Beaumont TBM
- Chalk & Gault Clays
Robbins Rock TBM`s

1950`s 1960`s 1970`s

Based on ideas by Charles Wilson  USA 1850
Types of Rock tunnelling machine
Main Beam; Gripper; Single & Double Shield and VDM’S
My favourite TBM!

Seli Double Shield. First TBM to successfully tunnel under the Himalaya’s in squeezing, high water pressure ground-- 2015
Mr I Bohn Sorumsand laboratory 1922
Tokke Hydroelectric Project 1967 -1 m dia
Follo Line 2019
More to follow in future ..

`Norway to begin new TBM era` TJ 2014
3.0 Recent Significant `soft` Influences

- Pressure on cities –more urban `shallow tunnelling` eg metro`s
- More confidence ....therefore More work !!!
- More competition & ..
- Value for Money procurement
- As a result....*Better served by The Market*
- Better training & skills
- More research funding
- Attract talent & diversity
- Better risk management approaches
- Climate influenced design ..carbon reduction
- Resilience/ Sustainability /Mobility /Public Health
- More empathy with owners /public/media
- **Urban tunnelling is more popular !**
- **Tunnelling is `sustainable` & effective**
Recent Key Advances

- Safety Culture/legislation
- Control and process
- Materials science
- Improved mechanisation
- Skills/talent /training
- Proactive Market
- Procurement & Contracts
- Computing power/ managing data
- Prediction /AI

What does this mean for the future?
This used to be the future!
Is this the future?
This is Elon

He thinks this is the future!

Elon wanted a safe payment method, so he created PayPal.

Elon wanted to drive an electric car, so he founded Tesla Motors.

Elon wanted to go to space, so he created SpaceX.

Elon wanted faster transportation, so he is developing the Hyperloop.

Elon's now into tunnelling -- OMG!

Elon does not complain how bad the world is.

He is changing the world.

Be like Elon.
Las Vegas bets $48m on Elon Musk’s tunnel vision
Elon ‘thinks’ The Boring Company can complete the tunnel by the end of 2019.

Dated May 24, 2019 – 10:45 GMT (11:45 BST) | Topic: Innovation
The future will include …

- Effective data management
- Big and Bigger Data; Digital Platforms; BIM level 7 & beyond!
- AI Computing, algorithms, intuitive `machine`s & improved analysis
- Better controls
- Improved control of ground movement
- Efficiencies in logistics—segment & materials handling, productivity
- Safety, health and welfare
- `Social value`
- Less underground labour, more automation & mechanisation (carbon efficient too)
- Next generation materials—grouts, additives, fibres, graphene, recyclable plastics, self healing materials
- Need to improve to make tunnelling affordable & effective
- China will want to sell you a TBM

• Knowing what we don`t know now!
TBM future --- areas for improvement, development..?

- Business model
- More automation
- Automatic ring build
- Logistics – a critical area!
- Face mapping
- Soil conditioning
- Skills & training
- Continuous tunnelling
- Supply chain
- Service as a `value`
- Long term relationships & collaboration contracts
- Early --Earlier involvement
- Gasket design
- Segment design and handling
- Tail seal
- Muck disposal
- Cutter wear improvements
- Re use & Renovation of TBMs
- Safety and welfare
5.0 What can owner`s do re the use of TBM$s?!

Our wonderful clients!

IT MUST BE DONE.

Owner /Client !!

I`LL NEVER LET YOU WIN.

Negotiations !
What can owners do?

9 helpful hints re TBMs

~Less client prescription – over prescription is not clever or helpful! Performance specification -- not detailed Specification
~Procurement of TBM is a key influence in Metro, Water Tunnel projects - get TBM supplier in early
~Improve Risk Sharing – client has to manage some risks
~Ensure Fair Financial Practices – reward value
~Responsible capitalism – R&D eg Tideway lining idea
~Proactive Carbon Reduction - no freeride on this planet
~Share lesson’s learned – not just the good news
~Promote automation - to reduce labour
~Don't buy just on price - value and service / TBM is not a commodity
• Have a good conference
• ..and thank you Norway for being a proactive global influence in tunnelling

• Takk!

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