



NTNU – Trondheim
Norwegian University of
Science and Technology

Estimation of soft ground and excavation tool life in TBM tunnelling

Brief introduction to Pål Drevland Jakobsen's PhD work
(2010-2013)

TBM applications III. Trondheim November 2019.

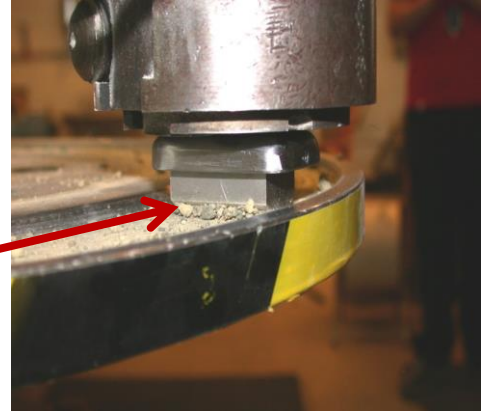
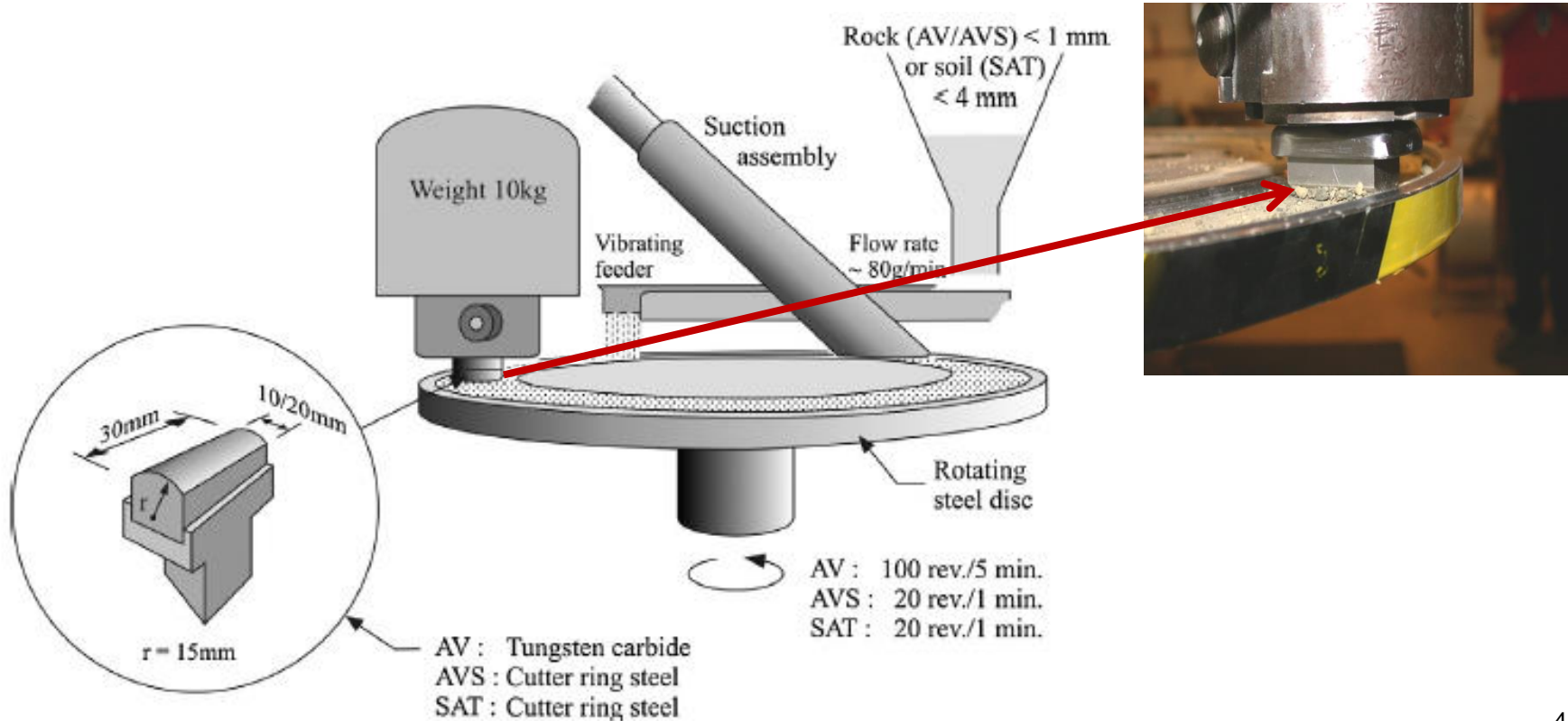
Contents

- Background – why research on soft ground abrasivity in Norway?
- Examples of laboratory work
- Examples of field work
- Aftermath and conclusions

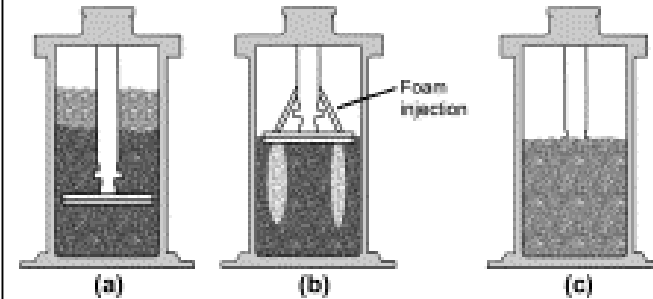
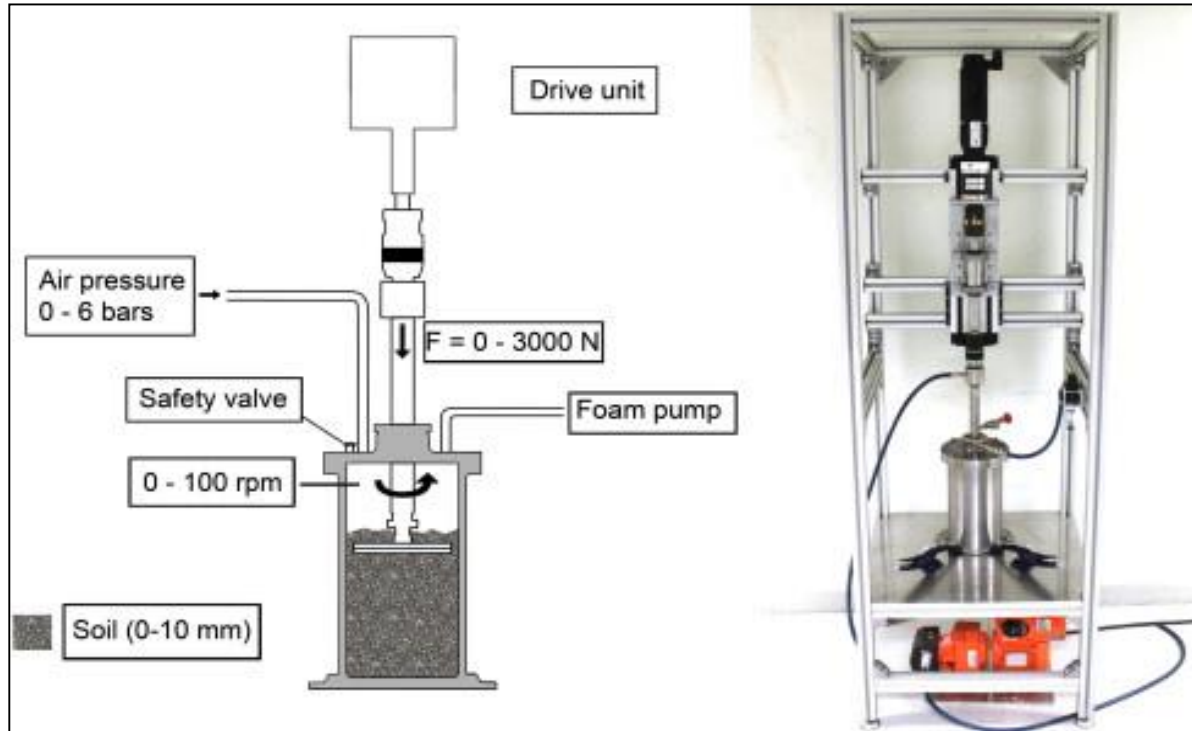
Background

- Request from a contractor to quantify the abrasion properties of soil samples (2005/2006)
 - Validity check of existing hard rock test methods on soil and soft ground
 - NTNU/SINTEF's experience on hard rock drillability and wear estimation from over 250 km of bored hard rock tunnels in Norway (and elsewhere)
- Some magazine publications in 2006 initiated several commercial laboratory tests on soil abrasivity for TBM applications

Soil Abrasion Test



Soft ground abrasion tester



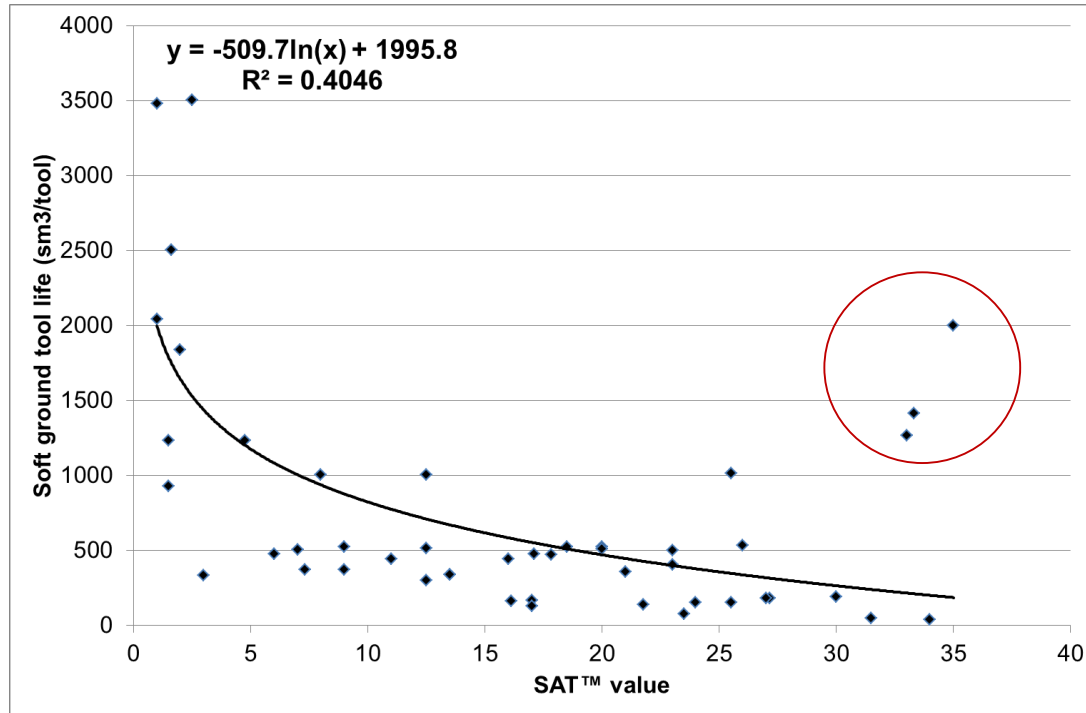
Field work consisted of...

- Enabling trust between the “owners of the data” and the research!
- Gathering geotechnical data and samples for laboratory
- Gathering tool life data (tool replacement logs)
- Gathering TBM production data (mm/rev, use/not use of soil conditioning additives, shift reports, torque ++)

Field studies

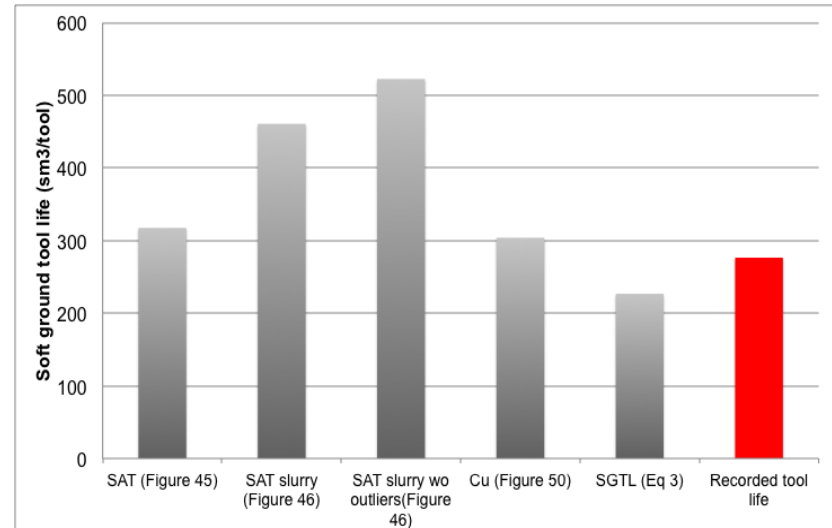
Project number	Face support	Approximate diameter [m]	Approximate tunnel length included in the study [m]	Region	Site visit
1	Slurry	5.5 m	5500	North America	
2	Slurry	13 m	5700	Central Europe	
3	Slurry	3.125 m	3300	Middle- East	
4	EPB	6.2 m	3 x 3000	Middle-East	✓
5	Slurry	3.04 m	375	Central Europe	✓
6	Slurry	2.2	1200	Central Europe	✓
7	Slurry	2.2	900	Central Europe	✓
8	Slurry	3	140	Central Europe	✓
9	Slurry	3	200	Central Europe	✓
10	Slurry	3.1	1200	Middle-East	✓
11	EPB	6.2	7500	South Europe	
12	EPB	6 m	2 x 2500	North America	
13	EPB	6.5 m	2 x 3000	South Europe	
14	EPB	9.5 m	6000	South America	
15	EPB	6 m	7500	South Europe	
16	EPB	2 m	700	South-east Europe	✓

Example of relation between SAT and tool life



Validity check of tool life estimators

- The estimators fit to the recorded tool life of the first 480 m of an ongoing slurry TBM project in Europe
- The estimators are in a range of - 22 – 85 % of the actual tool life
- TBM contractor expected replacement of tools after 1600 m (330 % deviation)
- Disc cutter consumption not taken into account (20 discs)



Conclusive remarks

- **SAT testing**
 - From 211 test results (2010), to 313 (2013), to 505 (2018)
 - Commercially available and used test (from design to claim)
 - Several replica test devices around the world
- **SGAT**
 - Some research on the effects on bentonite after the PhD
- **Soft Ground TBM tunnelling**
 - Joint research project with Hyundai on soft ground TBM performance and wear.

Thesis may be downloaded at

https://www.researchgate.net/publication/314157426_Estimation_of_soft_ground_tool_life_in_TBM_tunnelling