

FEEDBACK

## Optimum advance for long distance TBM drives

Jan  
2014

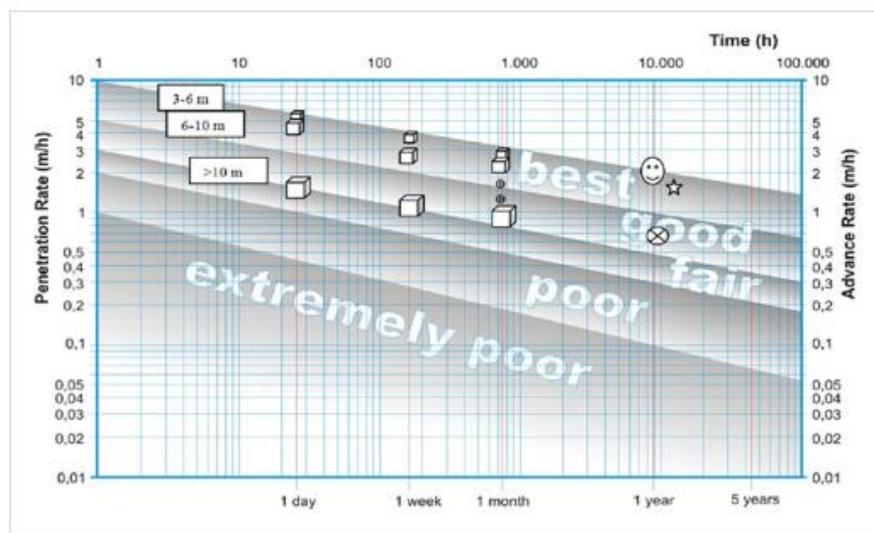
Dr Nick Barton, Nick Barton & Associates

In a *Letter to the Editor*, Dr Nick Barton examines the concept presented in the article by engineers and scientists in Norway to excavate long distance TBM drives under the sea to develop off-shore oilfields and replace the current oil platform technology.

I read with interest the article by Eivind Grøv and NTNU/Sintef colleagues about the continued interest in multiple TBM tunnels for personnel access and pipeline transport/production to-and-from off-shore petroleum locations, in their article [Subsea tunnels for oilfield development](#), *TunnelTalk*, Nov 2013.

This of course shows some interesting developments in relation to the Troll-i-Fjell project that some of us worked on in Norway in the mid-1980s for the company Petromine. The stability of circular openings in some assumed weaker sedimentary rocks was the focus for NGI studies at that time.

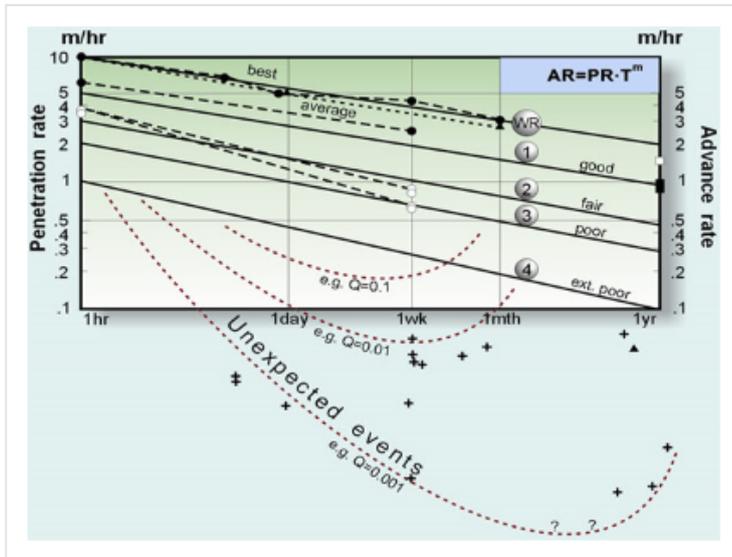
The purpose for this letter is to show and discuss where TBM world records plot on the  $Q_{TBM}$  deceleration plotting routine, based on 1,000km of TBM case records using mostly open-gripper TBMs (Fig 1). In the same diagram, the predicted Grøv *et al* "283m/wk average" advance is plotted as a star, assuming this is the 'constant' rate of progress converted to m/hr. In relation to world record monthly rates, shown as two small circles on Fig 1, it would indeed appear to be "by far world record speed" and shows the need of continuing the deceleration out to performances seldom achieved (Fig 2).



**Fig 1. Synthesized present world-record data for different sizes of TBMs using a log-log-log plot of penetration rate (PR) on the left axis only, advance rate (AR) in the remainder of plotted area, and time (T) as total hours**

The world record performance at present is recorded as 16km in one year, providing a mean advance of 2m/hr. This is better than a mean of 283m/wk, so there is hope for this predicted performance (see the smiling face at 2m/hr mean for one year on Fig 1).

The results in Fig 1 are based on data provided by The Robbins Company for all sizes of machines and including data for projects using TBMs supplied by other manufacturers. Day, week and month records (given in meters) have been converted to uniform m/hr rates by dividing by the assumed 24hr, 168hr and 720hr. Data from eight countries are represented chiefly from the USA and China. The record **mean monthly** data plots at advance rate (AR) = 1.7m/hr for the 3m to 6m TBM diameter class and at AR = 1.1m/hr for TBMs in the 6m to 10m diameter class. This is shown as the two small circles on Fig 1. The larger crossed-circle to the right is 54 weeks for 5.8km of the Svea Tunnel, achieved as the current drill-and-blast excavation record set by Norwegian contractor LNS. The tunnel was driven in coal-measure rocks and required significant shotcreting and bolting due to varied Q.



**Fig 2. Trends from open-gripper case records representing 145 cases and approximately 1,000km of TBM tunneling<sup>(1)</sup>**

course, significantly less than the "generous" 210 weeks mentioned in the article for completion of a project that comprises drill-and-blast tunnelling of the access ramps and crystalline rock kilometers, the three 22km TBM tunnels, and excavation caverns etc.

Grøv and his colleagues mention the results from the Fullprof software, applying the NTNU prognosis model estimate of 283m/wk, based on various feasible assumptions concerning cutter life and joint/bedding spacing. Rock mass strength is not mentioned but presumably is included, as in the  $Q_{TBM}$  prognosis method. As a weekly result this 283m/wk converts, by division with 7 days x 24hr, to a mean 1.68m/hour, which would indeed be a world record for a TBM in the 6m to 10m diameter range, if considered as a monthly average, or if continued for 22km which would imply 77.7 weeks, or 1.55 years, for completion, assuming 50 weeks of 7 day x 24hr production. Reaching the star in Fig 1 is indeed a significant goal.

The authors Grøv *et al*, 2013, mention that "scheduling would require a TBM in each of the parallel tunnels to operate simultaneously and at high advance rates, working around the clock and for several years through challenging ground conditions". However, it is necessary to reconcile the presumed 77.7 weeks theoretical result with the "several years", as access to get the TBM in place is going to use a significant part of the predicted overall 210 weeks. It is indeed wise to assume that 283m/wk would not apply when there were challenging conditions.

Regards,  
Dr Nick Barton

#### Author references

1. Barton, N. 2013. TBM prognoses for open-gripper and double-shield machines: challenges and solutions for weakness zones and water. *FJELSPRENGNINGS-TEKNIKK-BERGMEKANIKK-GEOTEKNIKK*, Oslo, 21.1-21.17, Nov 2013. 
2. Barton, N. 2000. *TBM Tunnelling in Jointed and Faulted Rock*. 173p. Balkema, Rotterdam.

#### References

- [Subsea tunnels for oilfield development](#) - *TunnelTalk*, November 2013  
[Record drill+blast work in Norway](#) - *TunnelTalk*, January 2009

The five typical lines of performance in Fig 2. are the same as shown in Fig 1. There is some evidence, such as 56km of TBM tunnelling for the Guadarrama high speed railway tunnels in Spain, that very efficient double-shield operations could, at best, halve the general decelerations of data in Fig 2. The TBM world records plotted in Fig 1, however, using the same deceleration trend-lines, actually follow this general deceleration-with-time pattern, as do large EPB machines, but at much lower rates when operated in closed mode<sup>(1)</sup>.

The star in Fig 1 marks the presumed requirement for development of the sub-sea tunnels for oil-field production caverns as suggested by Grøv *et al* in their *TunnelTalk* article, if 283m/wk is indeed the intended mean. An estimated time of 13,095 hours or 77.7 weeks for one tunnel of 22km is of