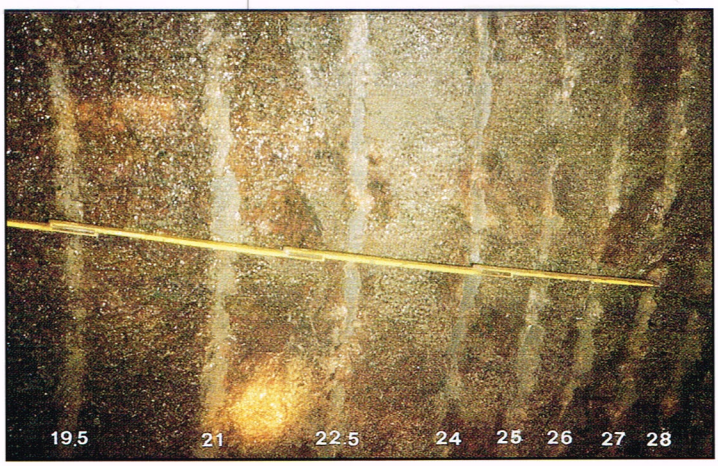
Robbins study promises efficiency and environmental benefits of recycled muck

A study completed by the Robbins Company in August 1994 may soon lead to a dramatic increase in the recyclability of muck produced during TBM tunneling. Results of tests conducted at the Äspö Project in southern Sweden on the effects of cutter spacing on rock chip size and rock boreability show that the dimensions of the chips produced during tunneling increase in proportion to increases in cutter spacing. Robbins personnel identified and produced chips with dimensions ideal for reuse in concrete and shotcrete aggregates in a process that promises to maximize the amount of muck suitable for recycling.

Recent tests in Switzerland confirmed that simple muck sieving produces material that can be used without any further processing in high-strength shotcrete and possibly even in 0/32 mm frost-resistant pump concrete. The Robbins Company study is a continuation of this effort to explore the potential for muck recycling by concentrating on ways to control the size of muck particles during tunneling.

The benefits of recycling muck are both environmental and economic. Reuse of excavated material results in improved natural resource management, and the decreased need for muck transport and dumping areas reduces project costs and damage to the environment.

The Äspö study also revealed that increased cutter spacing does not affect the rock boreability in a negative way. Also, fewer cutters per tunnel diameter generally result in less down time for cutter changes and lower energy consumption per cubic meter of excavated rock.



A pattern from the different cutter spacings appears on the rock face. Cutter positions 24 to 28 are spaced at 86 mm; positions 19.5 to 24 are spaced at 129 mm.

Tunnel bored by TBM usually requires rock support during excavation and lining of the finished tunnel. Both procedures include the use of shotcrete and concrete. With sources for suitable river sand and gravel now overexploited or restricted because of environmental concerns, an alternative supply of these materials is urgently needed. The potential for muck produced during TBM tunneling to be used in support and lining operations is an exciting and revolutionary development.

Over the past 30 years, improvements in TBM technology have led to increasing cutter diameters and loads to achieve higher penetration rates. Only recently, however, has cutter spacing increased as well, from the previous 65 mm to the current standard 86 mm. The Robbins study at Äspö represents progress toward increased cutter spacing as a standard design feature.

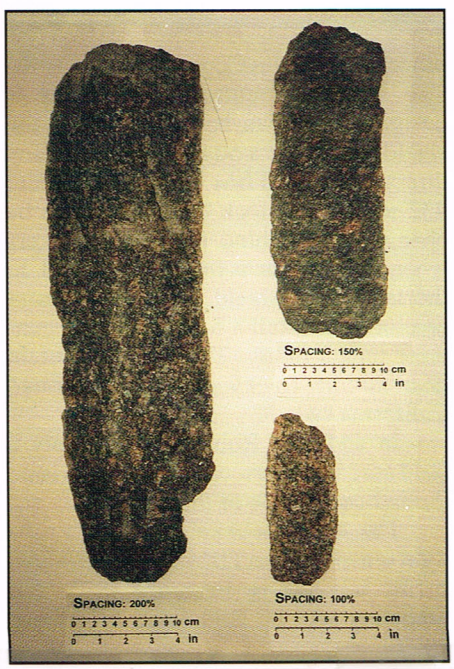
The Robbins Company conducted its tests at Äspö in Smalands granite with a typical rock strength of UCS 250 MPa, Point Load Index IS50 = 7.5 MPa and a CHERCHAR Abrasivity Index of 5.3.

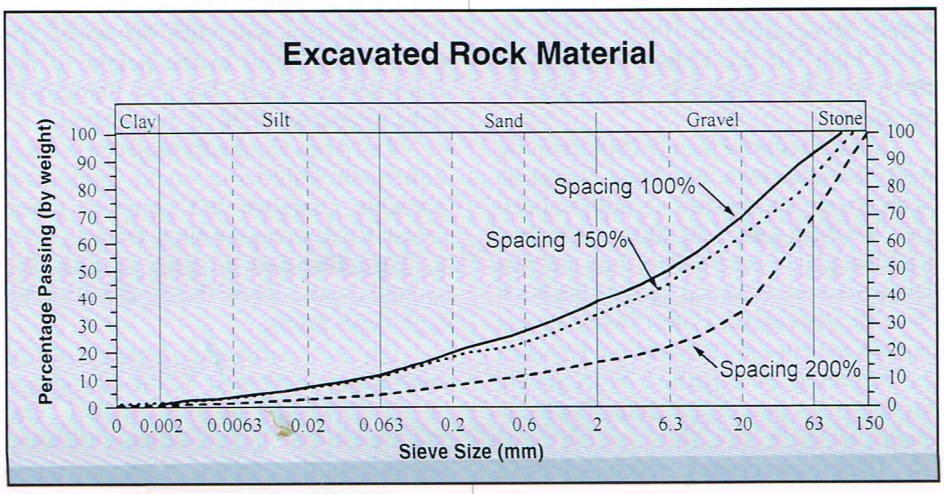
The TBM on the Äspö Project is the Robbins MK 15-1680. The 5.0 m dia machine's open cutterhead features 34 cutters, each 432 mm in diameter. Four additional cutter housings allow changes in cutter spacing from the original 86 mm to 129 mm and 172 mm.

Robbins personnel performed the testing in close cooperation with Äspö Project contractor SKANSKA of Sweden and in accordance with guidelines formulated by Switzerland's Geotest AG.

Muck analysis took place at cutter spacings of 86 mm (100 percent), 129 mm (150 percent) and 172 mm (200 percent). Boreability tests were conducted over a distance of 9.5 m at the 129 mm spacing and covered a length of 4.5 m at the 172 mm spacing.

The Geotest crew used sieving to analyze the 40 kg to 90 kg of muck collected during each test phase. The chips were sorted according to standard sieve





curves, rod sieve curves, chip dimensions and chip shape (cubic, flat, elongated).

Muck analysis led to the conclusion that increasing the cutter spacing by 50 percent increases chip thickness by 60 percent. Thickness of the flat chip produced during boring is the most critical dimension in determining muck recyclability, with a minimum of 0/32 mm required for concrete aggregate. In granite, the predominant rock type at Äspö, a cutter spacing of 107 mm is the narrowest setting that will produce such a chip.

In examining the sieve curves, the researchers found that increased cutter spacing reduced the amount of fine material in the muck samples. This results in a sand-gravel ratio after crushing that is more favorable to concrete production. Results also show increased thickness of relatively small rock debris, a development important to proper grain size distribution in the final material.

The Robbins study at Äspö is a significant step toward an environmentally and economically beneficial solution to the problem of muck disposal, even on projects involving challenging rock, such as granite. TBM boring with greatly increased cutter spacing could lead to a new era in hard rock tunneling. ¤

Adapted with permission from paper presented at LUCIA 1994 TBM Symposium: E. Büchi and C. Thalmann.

BREAKTHROUGH

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