1 Introduction

A man who carries a cat by the tail learns something he can learn in no other way.

~Mark Twain

This book is written with the intention of sharing the experiences gained in difficult ground conditions with TBMs in Turkey.

Turkey is in a tectonically active region; at a large scale, the tectonics of the region are controlled by the collision of the Arabian Plate and the Eurasian Plate. The Anatolian block is being squeezed to the west. The block is bounded to the north by the North Anatolian Fault and to the south-east by the East Anatolian Fault. The effects of North and East Anatolian Faults on TBM performances in Kargi energy tunnel, Dogancay energy tunnel, Nurdagi railway tunnel and Uluabat energy tunnels are explained in detail giving the causes, effects and precautions to be taken in order to eliminate the problems created by two large sets of faults. Some information is also given about the most difficult tunnels (Ayas and Bolu) that have ever been excavated by drill and blast method.

We believe that the Selimpasa and Silvan tunnels also provide unique experience since one suffered a methane explosion in the EPB chamber and the other hit a natural gas reservoir completely destroying a TBM and its related accessories.

The clogging of a TBM, as is encountered in clay-containing ground, has extensive consequences for the construction process and can severely affect the performance of the machine, increasing the torque, thrust and specific energy and lowering the advance rates with the extra cleaning efforts needed. Chapter 10 is written with the intention of clarifying the subject by giving three examples of tunneling projects in Turkey: Suruc Tunnel plus Selimpasa and Zeytinburnu Ayvalidere, two wastewater tunnels that were studied in detail in this respect. Experimental studies performed in the soil conditioning laboratory indicated that regular application of foam selected by the contractor was adequate to solve the sticking and clogging problems in Selimpasa, while an anti-clay agent different from the one selected by the contractor was suggested for Zeytinburnu. The representatives in the two cases applied the laboratory results in the field. The field measurements validated the experimental studies and the net advance rates of the EPB-TBMs increased at least 1.3 to 1.5 times and the stoppages due to clogging problems were reduced to normal ranges.

One of the most difficult tunnels ever opened in Istanbul was Beykoz sewerage tunnel, which encountered a complex geology. The need to change disc cutters to chisel cutters, CCS-type discs cutters to V-type disc cutters, excessive disc cutter consumption and TBM squeezing problems were also experienced in this tunnel.

Istanbul has a very complex geology, and in the near future the majority of TBM tunneling projects of Turkey are planned to be carried out in this fast-growing city. Bearing in mind this reality, the main objective of Chapter 3 is to show how the optimum selection of TBM type for Istanbul, has gradually changed from open type TBM (Baltalimani Tunnel), to double shield TBM (Moda-Tuzla Tunnel), to slurry type TBM

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(Marmaray tunnels) and finally to EPB-TBMs over the past 25 years. This gradually progressing selection based on the complex geology of Istanbul is a typical example to the concept of ‘learning costs’. A model of the performance prediction of EPB-TBMs is also given based on experiences and data collected in several metro tunnels as Uskudar–Cekmekoy and Mahmutbey–Mecidiyekoy metro tunnels.

As already explained, Turkey is widely affected by two major fault systems, the North Anatolian and East Anatolian Faults. These two fault systems and magmatic inclusions ‘dykes’, fracture the host rock creating problematic blocky ground for TBM excavations. This problem is explained in Chapter 7 which is aimed to explain the effect of blocky ground on TBM performance and the mechanism of rock rupture in front of the TBM. Typical examples are given from Kozyatagi–Kadikoy Metro tunnels.

The causes and effects of TBM blockages are explained for Kadikoy–Kozyatagi metro tunnels. Eleven different TBM face collapses and blockages which have occurred in very complex geology within the Kadikoy–Kozyatagi Metro tunnels are analyzed considering TBM parameters such as opening ratio, working modes and geological parameters. It is determined that the TBM excavation parameters fluctuate while approaching the collapse regions, and these parameters show an increasing or decreasing trend insite ‘during collapse’ region and it is concluded that this trend is a good indicator of face collapses, which will serve as a guide to foresee critical areas in front of TBM.

Squeezing of TBM or jamming the cutterhead is a nightmare for tunnel engineers, since it affects machine utilization time and realization of the project scheduled time. The salvation (rescue) of a jammed cutterhead can considerably reduce the mean advance rate. This problem was studied for Kargi, Uluabat and Dogancay tunnels, where the causes and effects of TBM squeezing are discussed with respect to remedial works needed for these three tunnels.

Cutter consumption is one of the most important cost items in mechanized tunneling due to replacement costs, cutting efficiency (penetration rate reduction with worn tools), and also man-hours spent on replacement. Yamanli II HEPP Tunnel, Buyukcekmece wastewater tunnel, Beykoz sewerage tunnel and Uskudar–Umraniye–Cekmekoy–Sancaktepe Metro Tunnels are detailed in this respect in Chapter 12.

Probe drilling ahead of a TBM is a time-consuming and tedious operation. If it is not interpreted correctly, it can give misleading results in complex geology. The research study summarized in this book shows that for correct interpretation of the drilling data, muck from the excavated area should be collected continuously for petrographic identification and strength tests. Two typical examples are Melen water tunnel and the Kargi Project. The experience gained in the umbrella arch in front of the TBM in the Kargi Project is also shared within this book.