

## 1. Introduction

The "New Austrian Tunneling Method" (NATM) was originally applied for tunnels in rock. Since the 1970ies, however, this tunneling method was carried out more and more also in soft rock with low overburden and in urban areas. Because of the outstanding importance of the shotcrete (sprayed concrete) for the application of this method the denotation "Sprayed Concrete Lining Method" or simply "Shotcrete Method" is mainly used in Germany.

The NATM is a construction method, which is very adaptive according to changing subsoil conditions and changing shapes of cross-sections. Interacting with the subsoil the primary function of the shotcrete membrane is to form an arch around the tunnel, which is capable to carry. With a favourable shape of the tunnel's cross-section and an adequate sequence of construction stages it is possible to avoid or at least to minimize bending moments and shearing forces in the shotcrete membrane. Thus, large underground openings can be supported by relatively thin shotcrete membranes. With an adequate design also the subsidence on the surface can be limited to relatively small values.

Stability analyses, in which the interaction of the subsoil with the support are modeled in a realistic way, however, serve as a prerequisite for a successful tunnel heading using this method. The authors are convinced that this is possible only by numerical computation methods. Stability analyses, therefore, should be carried out generally using finite element codes. A powerful tool, which is suitable also for three-dimensional problems, is the finite element code FEST03 developed by WBI and documented in the volume WBI-PRINT 4 (Wittke, 2000). Since more than 20 years this program, which in this period of time has been improved and enlarged several times, serves as an valuable device for a safe and economic design of tunnels.

The design of a tunnel according to the NATM is carried out stepwise with the following working steps, which are to be repeated several time, if required:

- Geotechnical investigations of the ground and groundwater conditions.

- Evaluation of the soil and rock mechanical parameters, based on test results as well as experience.
- Stability analyses for both, the stability proof of the tunnel and the design of the shotcrete membrane as well as the interior concrete lining.
- Design and assessment of excavation methods and support measures (excavation classes).
- Supervision of stability by geotechnical mapping and monitoring during construction.
- Back analysis of the results of measurements.

The authors of the given volume WBI-Print 5 since more than 20 years are experienced with the stability analysis and design of tunnels carried out by the NATM. With this volume it will be attempted to transmit this experience by case histories.

In Chapter 2 an overview on the fundamentals of the NATM is given. Here also new developments such as non-alkaline shotcrete are treated. Moreover in Chapter 2 geotechnical mapping and monitoring, which are essential parts of this tunneling method, are dealt with.

Advancing crown headings with open and closed invert are treated in the Chapters 3 and 4. In each chapter three case histories are presented.

Advancing sidewall tunnel headings are subject of Chapter 5. Here also three case histories are documented.

In Chapter 6 two more case histories are presented, in which a full-face excavation at least in sections were carried out.

Two case histories for headings under the protection of jet grouting columns are dealt with in Chapter 7.

The documentation of the case histories is, as a rule, arranged as follows:

- Description of the structure,

- characterization of the ground and the groundwater conditions,
- design and excavation classes,
- stability analyses and the design of the shotcrete membrane,
- excavation methods and support measures carried out during construction,
- geotechnical monitoring and interpretation of measurements,
- conclusions.