



Handbook of Tunnel Engineering II

Basics and Additional Services for Design and Construction

Bernhard Maidl
Markus Thewes
Ulrich Maidl

WILEY

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Tunnel engineering is one of the oldest, most interesting but also challenging engineering disciplines and demands not only theoretical knowledge but also practical experience in geology, geomechanics, structural design, concrete construction, machine technology, construction process technology and construction management. The two-volume "Handbuch des Tunnel- und Stollenbaus" has been the standard reference work for German-speaking tunnellers in theory and practice for 30 years. The new English edition is based on a revised and adapted version of the third German edition and reflects the latest state of knowledge. The book is published in two volumes, with the second volume covering both theoretical themes like design basics, geological engineering, structural design of tunnels and monitoring instrumentation, and also the practical side of work on the construction site such as dewatering, waterproofing and scheduling as well as questions of tendering, award and contracts, data management and process controlling. As with volume I, all chapters include practical examples.

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and Construction

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B. Maidl, M. Thewes, U. Maidl

**Handbook of Tunnel Engineering II
Basics and Additional Services for Design
and Construction**

Dedicated to My Grandchildren

Maximilian

Leon

Antonia

Frederik

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Foreword to the English edition

The “black book of tunnelling” has become a standard work in German-speaking countries since its first German edition in 1984. It can be found on every tunnel site and in every design office – whether contractor or consultant. Students at universities and technical colleges use it as a textbook.

For many years, colleagues from abroad have been asking me for an English edition. Now the time has come to publish the two-volume book in English. An important step was that the publisher of the first German edition, VGE, gave their permission for the publishing of the English edition by Ernst & Sohn, Berlin. Special thanks are due to Dr. *Richter* from Ernst & Sohn for his successful negotiations. However, preparation of the text for the translation showed that the 3rd German edition required updating and extending. In particular, the standards and recommendations have been revised. This will all be included in a 4th German edition, which will be published soon. Changes to the standards and recommendations are given in this edition, with the references stating the latest version.

As with all books, the English edition has also required the collaboration of colleagues. Professor Dr.-Ing. *Markus Thewes*, who has succeeded me as the holder of my former university chair, and my son Dr.-Ing. *Ulrich Maidl*, managing director of the consultant MTC, have joined me in the team of authors. Dipl.-Ing. *Michael Griese* from MTC is the overall coordinator, assisted by Dipl.-Ing. *Stefan Hintz* from MTC. I thank all those involved, also the translator *David Sturge* and the employees of the publisher Ernst & Sohn in Berlin.

Bochum, in September 2013

Bernhard Maidl

Writing without violence is impossible.
I constantly put myself under pressure.
Violence is perhaps not the right word.

Daniel Boulanger

Foreword to the 3rd German edition

The above quotation introduced the complete revision of the second volume for the 3rd German edition. This became necessary after 15 years because not only the tunnelling technology in the first volume has developed enormously but also the standards and regulations have been revised or harmonised in the European Union. Under these premises, all chapters have been reworked and extended, partly based on my other books like shotcrete, steel fibre shotcrete, shield and TBM tunnelling as well as more recent publications.

The chapter “Dewatering during the Construction Phase” has been extended and is now called “Dewatering, Waterproofing and Drainage” in the second volume; this includes detailed information about hardness stabilisers.

As already in Volume 1, my employees have supported me in every way, although I have also received external help. For example, Dr. *Heimbecher* revised the section about road tunnels in Chapter 1 and Mr *Chromy* contributed to the section about the EU machinery directive in Chapter 8.

I wish to thank them all, and also the collaborators on my former books, which we have referred to for the revision work. Great thanks are also due to the many helpers from the consultancy Maidl + Maidl and for the contributions of several machine manufacturers and the publishers Glückauf.

Bochum, in January 2004

Bernhard Maidl

Foreword to the 2nd German edition

The good sales of the “Handbook of Tunnel Engineering” have also accelerated the publication of the second volume. Numerous ongoing and future large tunnel projects lead to a great demand for relevant literature. Reference books about design, tendering and construction are of great importance today, whether for instruction at universities, for practical application in consultancies and on construction sites, but also for the individual engineer interested in gaining further knowledge. So I am personally very satisfied to find the “Handbook of Tunnel Engineering” in use in design offices, on site, and also repeated in the text of university lectures.

On the threshold to the next century, with tunnels becoming ever longer and being constructed under ever more challenging conditions, construction methods are also demanded to comply with ecological, environmental and economic requirements. The necessary development potential covers all construction methods, both in conventional and mechanised tunnelling. The initial requirements, specifically the description of the geology and hydrology with the associated structural verifications and measurements, the environmental requirements, and also the special features of scheduling and cost planning with the associated contractual provisions, are likewise significant factors. This book covers all these subjects.

A complete revision for a new edition would naturally represent the latest state of information, but this is not achievable in the available time. The reader must therefore be asked to consider this when one or other innovation has not yet been included.

I wish to thank the publisher for their processing.

Bochum, in October 1995

Bernhard Maidl

Research and Technology demand ever more Interdisciplinary Knowledge. It is almost a characteristic of our Time that scientific and technical Progress is increasingly taking place at the Interfaces of traditional Professions.

Karlheinz Kaske, 1987

Foreword to the 1st German edition

Four years after the publication of the first volume, work on the second volume is at last complete. This Volume II devotes its first chapters to the fundamentals of design, aspects of engineering geology, structural verifications and instrumentation for monitoring with the intention of providing a clear classification of the known theoretical and practical methods. The composition of the chapter “Structural design verifications, structural analysis of tunnels” proved demanding despite the intensive assistance of Herr Dipl.-Ing. *Jens-Detlev Wolter*. Although tunnels are engineering structures, their structural analysis and calculation cannot be undertaken like structures above ground. Their load-bearing behaviour is decisively influenced by the construction method, also including for the tunnel engineer the time factor as construction progresses. This factor is at least as significant as the effect of the rock mass around the tunnel considered as a “construction material”.

The construction method is emphasised in the second volume just as in the first. Construction process technology in tunnelling is a prime example of interdisciplinary research: only an engineer who can master the technical basics of all influential factors can work competently. I could not and did not want to offer a qualitative or even quantitative evaluation of calculation procedures. Experienced structural engineers will form their own opinion. However, construction experience and calculation examples from recent rail, road and underground railway tunnels have been included.

This Volume II also deals with auxiliary works such as dewatering, measurement and control technology and scheduling. The control technology for tunnel boring machines is developing rapidly, particularly for shield machines in different soil types.

Similarly to Volume I, Volume II also includes extensive tables and illustrations in order to represent the idea of a handbook. The examples are taken from numerous newer construction projects.

In the production of this Volume II, I have relied heavily on the assistance of my colleagues at the Institute for Tunnelling and Construction Management. I thank Dipl.-Ing. *Jens-Detlev Wolter*, Dr.-Ing. *Dieter Handke*, Dipl.-Geophys. *Günther Eichweber*, Dr.-Ing. *Harald Brühl*, Professor Dr.-Ing. *Dietrich Stein*, Dipl.-Ing. *Karl-Jürgen Athens* and

Dipl.-Ing. *Jürgen Brenker* for their tireless motivation and months of collaboration, and I particularly wish to thank Dipl.-Ing. *Uwe von Diecken* for the overall leadership of the group. Thanks are also due to Professor Dr.-Ing. *Werner Brilon*, chair of transport I at the Ruhr University, Bochum, for collaboration on Section I.1 in regard to transport technology. I thank my brother Dipl.-Ing. *Reinhold Maidl* for his help and the help of the consultancy, particularly for the assistance with the work load at all times.

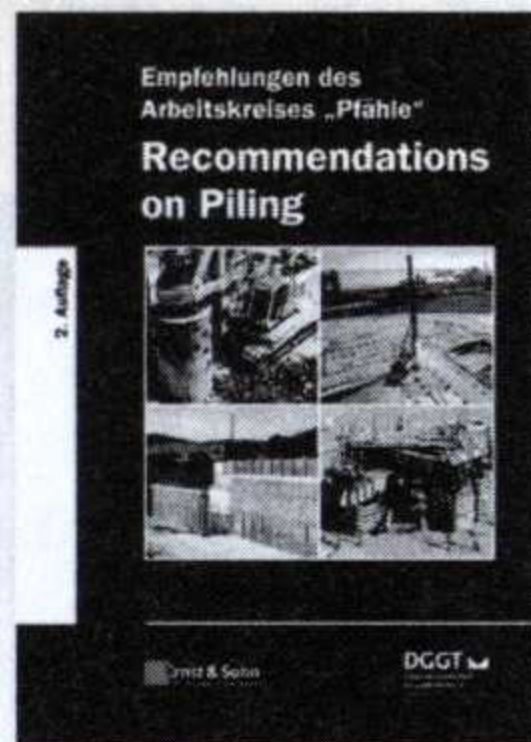
I thank the ladies at my chair and the consultancy, Frau *Agatha Eschner-Wellenkamp* and Frau *Hildegard Würdehoff*, and at the drawing office led by Herr *Helmut Schmidt* for their industrious help in the production of the work.

The publisher has assisted me greatly with this volume by looking through the manuscript critically, suggesting improvements and have also presented the work excellently.

Let us hope that Volume II “Basics and Auxiliary Works in Design and Construction” can find its way, as Volume I already has, into the hands of the engineers working for contractors, clients and their supervisors, and not least of the students at the various further education establishments.

Bochum, in May 1988

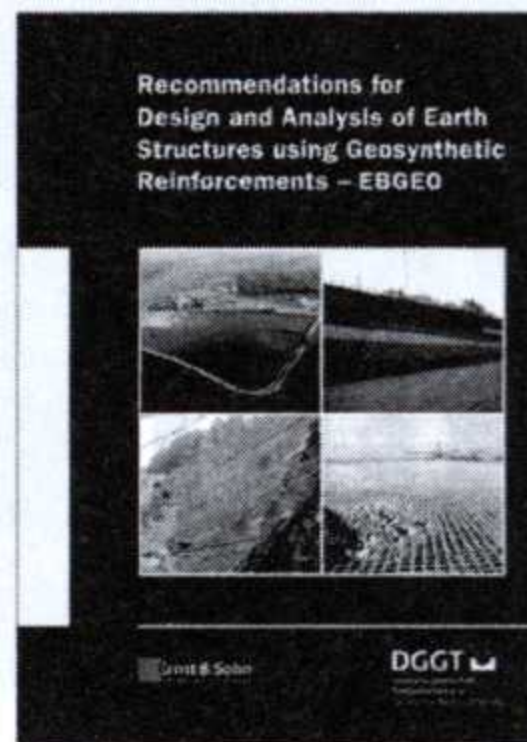
Bernhard Maidl



DEUTSCHE GESELLSCHAFT
FÜR GEOTECHNIK E.V. (ED.)
**Recommendations on
Piling**

2012. approx. 480 pages,
approx. 181 fig., approx. 98 tab.,
Hardcover
approx. € 89,-*
ISBN 978-3-433-03018-9
Date of Publication:
End 2012

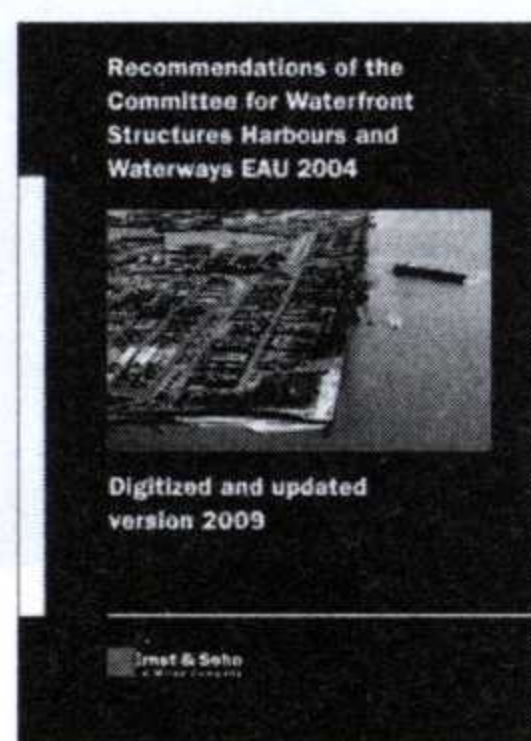
■ This handbook provides a complete overview of pile systems and their application. It shows their production as well as their analysis providing the new safety concept based on numerous examples for single piles, pile grids and groups. These recommendations are considered rules of engineering.



DEUTSCHE GESELLSCHAFT
FÜR GEOTECHNIK E.V. (ED.)
**Recommendations for
Design and Analysis of Earth
Structures using Geosynthetic
Reinforcements - EBGeo**

2011.
316 pages, 112 fig., 26 tab.,
Hardcover.
€ 89,90*
ISBN 978-3-433-02983-1

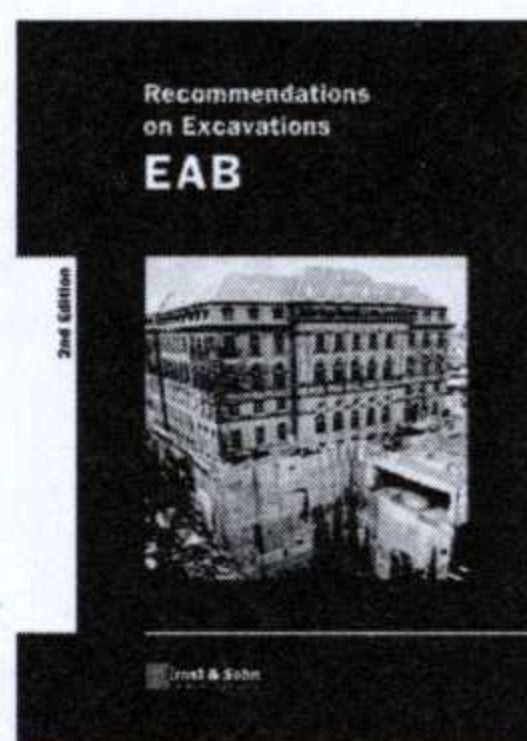
■ The recommendations deal with analysis principles and the applications of geosynthetics used for reinforcement purposes in a range of foundation systems, ground improvement measures, highway engineering projects, in slopes and retaining structures, and in landfill engineering.



ARBEITSAUSSCHUSS
„UFEREINFASSUNGEN“
DER HTG E.V. (ED.)
**Recommendations of
the Committee for
Waterfront Structures
Harbours and
Waterways EAU 2004**

Digitized and updated version
2009
on CD-ROM
€ 125,-*
ISBN 978-3-433-02928-2

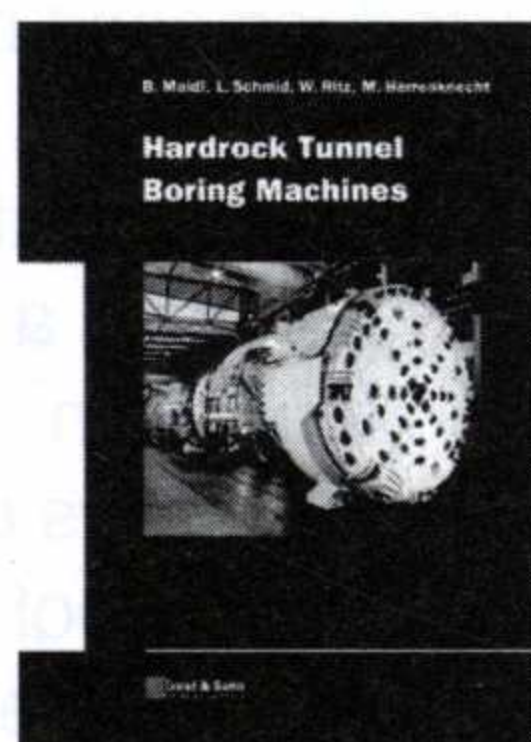
■ The English edition of EAU 2004 contains the safety concept with partial safety factors in accordance with the Eurocodes and corresponding German standard. Compared to printed edition modifications adopted by technical annual reports since 2006 are incorporated into the CD-ROM.



DEUTSCHE GESELLSCHAFT
FÜR GEOTECHNIK E.V. (ED.)
**Recommendations on
Excavations
EAB**

2., revised Edition 2008.
284 pages, 115 fig., 19 tab.,
Hardcover.
€ 69,-*
ISBN 978-3-433-01855-2

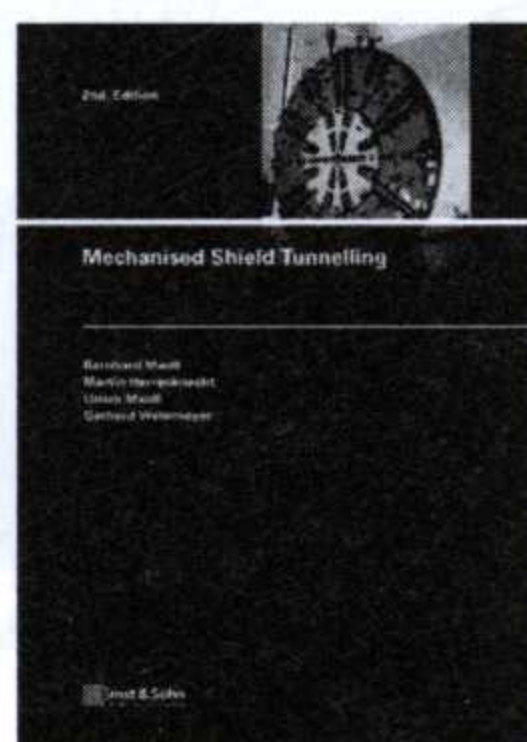
■ The beginning of any building project is an excavation. The aim of these recommendations is to harmonize and further develop the methods, according to which excavations are prepared, calculated and carried out. The recommendations are similar to a set of standards.



BERNHARD MAIDL,
LEONHARD SCHMID,
WILLY RITZ,
MARTIN HERRENKNECHT
**Hardrock Tunnel Boring
Machines**

2008. 343 pages, 256 fig.,
37 tab., Hardcover.
€ 102,-*
ISBN 978-3-433-01676-3

■ This book covers the fundamentals of tunneling machine technology, treating methods of rock classification for the machinery concerned as well as legal issues.

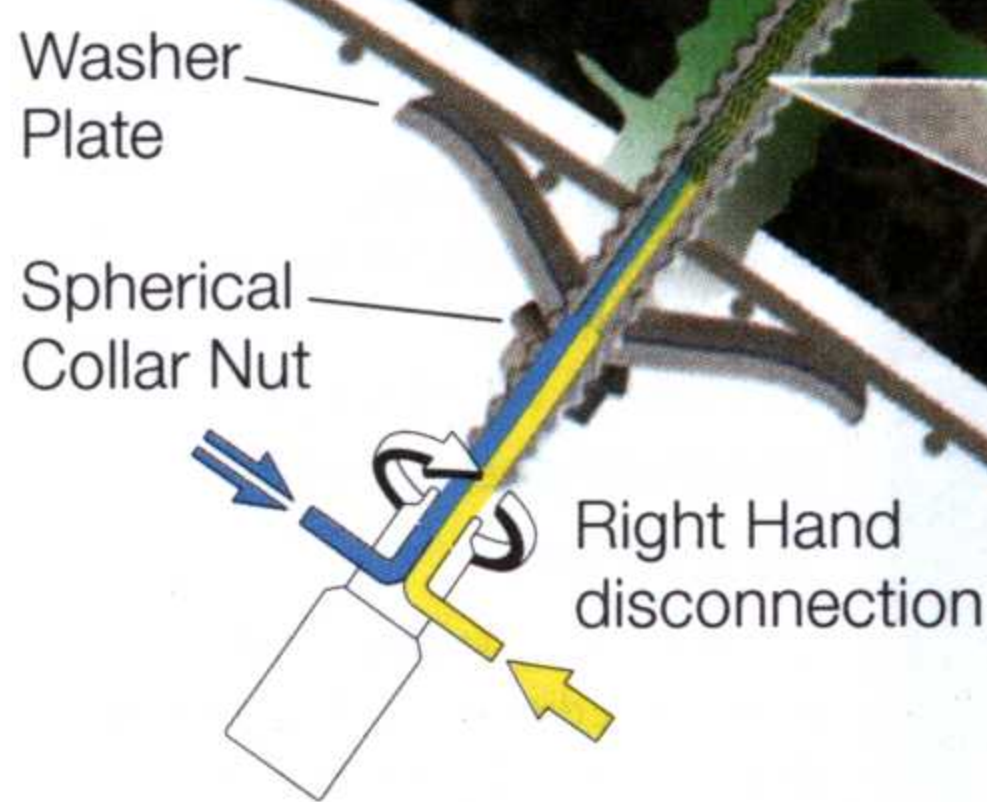


BERNHARD MAIDL,
MARTIN HERRENKNECHT,
ULRICH MAIDL,
GERHARD WEHRMEYER
**Mechanised Shield
Tunnelling**

2., completely revised and
enlarged Edition 2012. 490 pages,
468 fig., 44 tab., Hardcover.
€ 119,-*
ISBN 978-3-433-02995-4

■ This book presents the state of the art in mechanised shield tunnelling technology and the various types of equipment. It provides design approaches and structural advice while covering many questions on detailing.

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