

Recommendations on Piling (EA-Pfähle)



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für Geotechnik e. V.
German Geotechnical Society

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Preface of the English Version of the Recommendations of the Piling Committee of the German Geotechnical Society

(1) The present English version of the Recommendations of the Piling Committee of the German Geotechnical Society (Empfehlungen des Arbeitskreises „Pfähle“ – EA-Pfähle), is with a few exceptions a direct and complete translation of the 2nd edition 2012 of the German original. Even in case that some issues and, in particular, references might internationally not be known as in Germany, this approach was taken in order not to permit differing provisions between the German and this English version, if the latter is used in German speaking countries. It might also be possible that contractual or legal problems could arise between German and English speaking users if they could refer to a not identical translation.

(2) As outlined in Section 1, Germany has published the German language versions of the European design (e.g. Eurocode 7) and execution standards (e.g. EN 1536, EN 12699, etc.). So was EN 1997-1:2004-11: Eurocode 7: Geotechnical design – Part 1: General rules published in Germany as DIN EN 1997-1:2009-09: Eurocode 7: Entwurf, Berechnung und Bemessung in der Geotechnik – Teil 1: Allgemeine Regeln.

(3) For application in Germany, the standard DIN EN 1997-1:2009-09 was complemented with additional rules by DIN 1054:2010-12: Baugrund – Sicherheitsnachweise im Erd- und Grundbau – Ergänzende Regelungen zu DIN EN 1997-1 (Ground – Verification of the safety of earthworks and foundations) and by the National Annex EN 1997-1/NA:2010-12: Nationaler Anhang – National festgelegte Parameter – Eurocode 7: Entwurf, Berechnung und Bemessung in der Geotechnik – Teil 1 (National Annex – Nationally determined parameters – Eurocode 7: Geotechnical design – Part 1: General rules). The three documents were implemented together and their application is binding in Germany.

(4) Complementing the European execution standards, national specifications were published and implemented in Germany under the heading “DIN SPEC”.

(5) DIN 1054:2010-12: Baugrund – Sicherheitsnachweise im Erd- und Grundbau – Ergänzende Regelungen zu DIN EN 1997-1 (Ground – Verification of the safety of earthworks and foundations) frequently refers to the Recommendations of the Piling Committee of the German Geotechnical Society (EA-Pfähle) e.g. for the application of values based on well established experience for pile resistances, for the static and dynamic load testing, concerning pile resistances under cyclic loads, etc.

(6) Where this English version of the Piling Recommendations makes reference to the above mentioned German standards DIN 1054 or the DIN SPEC,

the English speaking user should know, that all technical contents of the German complementing standards to Eurocode EC 7 and the European execution standards are also covered in these Recommendations.

(7) This means that the user of the Piling Recommendations (EA-Pfähle), when consequently applying, also fulfils the provisions of the complementing standards implemented in Germany.

(8) Technical terms and symbols used in these Recommendations, if in addition to those of DIN EN 1997-1 (Eurocode EC 7-1), are listed in Annex A1 and, as necessary, explained in this English version.

(9) In addition, the text can contain notes to supply the user with additional explanations for technical issues which are common in Germany or making reference to international procedures.

(10) The Piling Recommendations are technical rules representing good and generally accepted codes of practice. They are the result of technical and scientific co-operation on honorary basis of the members of the Piling Committee of the German Geotechnical Society.

Preface of the 2nd German edition

(1) Germany has a long tradition of standardisation with regard to the execution and design of piled foundations and individual pile systems. The German ‘Piles’ standardisation committee (DIN NA 005-05-07 AA) and the German Geotechnical Society’s AK 2.1 ‘Piles’ Working Group (hereafter called as the Piling Committee), have cooperated on these topics for many years, with members sitting in both bodies. In recent decades this joint committee has compiled the piling standards DIN 4026 (driven piles), DIN 4014 (bored piles) and DIN 4128 (grouted piles), and the piling section of DIN 1054 (Section 5), and adapted the individual editions to meet current best practice.

(2) Since European standardisation began at the end of the 1980s, the committee has been tasked with accompanying the development of the European execution standards EN 1536 (bored piles), EN 12699 (displacement piles) and EN 14199 (micropiles) as a national mirror committee. It was also tasked to supervise the edition of the German language versions of the execution standards, namely DIN EN 1536, DIN EN 12699 and DIN EN 14199. In terms of pile analysis and design, the committee focused on the piling sections of DIN 1054:2005-01 and DIN 1054:2010-12, paying particular attention to the partial safety factor approach.

(3) To supplement this work, the Piling Committee decided to produce summary recommendations for pile analysis and design, of which the first edition was published 2007 as ‘EA-Pfähle’ and which are presented in the second edition. The ‘EA-Pfähle’ sees itself in the tradition of similar DGGT (German Geotechnical Society) recommendations such as EAB (Empfehlungen Arbeitsausschuss Baugruben – Recommendations on Excavations), EBGEO (Empfehlungen für den Entwurf und die Berechnung von Erdkörpern mit Bewehrungen aus Geokunststoffen – Recommendations for Design and Analysis of Earth Structures using Geosynthetic Reinforcements), etc., which are now well-established as best practice regulations.

(4) With the publication of the Eurocode standards handbooks for structural engineering and the handbook for Eurocode 7, Geotechnical Design – Part 1: General Rules (1st edition 2011), European standardisation in this field has, for the time being, come to a conclusion. The standards were implemented as binding building regulations in Germany with the cut-off date 01.07.2012. The handbook Eurocode 7, Geotechnical Design – Part 1: General Rules, contains as summary DIN EN 1997-1:2009-09 (Eurocode EC 7-1: Geotechnical Design – Part 1: General Rules), DIN 1054:2010-12 (Ground – Verification of the Safety of Earthworks and Foundations – Supplementary Rules to DIN EN 1997-1) and DIN EN 1997-1/NA:2010-12 (National Annex).

(5) DIN 1054:2010-12 refers to ‘EA-Pfähle’ at various points dealing with pile analysis and design, e.g. for the tabled values for pile resistances based on

well established experience. For formal reasons DIN 1054:2010-12 refers to the first edition of 'EA-Pfähle'; however, it is only with the this second edition that the technical link to the EC 7-1 Handbook [44] has been properly accomplished thematically. This is especially the case for analysis methods and for terminology with regard to the EC 7-1 Handbook [44], meaning that coherent and coordinated pile foundation analysis and design regulations are now available to the user.

(6) In addition, design related issues in terms of the European pile execution standards DIN EN 1536, DIN EN 12699 and DIN 14199 are also dealt with in 'EA-Pfähle'. A comparative classification of the pile systems used in construction practice (Section 2) simplifies correlation between the standards. Detailed regulations on static and dynamic pile testing (Sections 9 and 10), and quality assurance guidelines and methods (Sections 11 and 12) aim to promote technically high-quality pile construction.

(7) A new Section 13, not included in the first edition, deals with load-bearing behaviour and analysis methods for piles subjected to variable actions. Particular attention was paid to the load-bearing behaviour of piles under cyclic loads, such as often occur in foundations for wind turbines (offshore, onshore), but also in highway engineering, etc.

(8) Whereas the first edition of 'EA-Pfähle' was initially understood to be a draft, and at the time was only recommended for trial use, the draft character is no more applicable on this second edition. In the interim, the piling community has had the opportunity to test the provisions and pass on their comments and proposals to the Piling Committee. This is also the case for the new Section 13, which was previously published in a variety of organs. All statements on the first edition were dealt with by the Committee when compiling the second edition and, if justified, included. Appendices A5, A6 and D contain "informative" technical guidelines, not yet classified as best practice, but instead representing the current scientific view.

(9) In terms of the compulsory nature of the present recommendations 'EA-Pfähle', 2nd edition, the user is referred to the "Notes for the User" published in EAB (2006), 4th edition, Ernst & Sohn, which are applicable in a similar manner here.

(10) The German Geotechnical Society's Piling Committee (AK 2.1 'Piles' Working Group) asks to send any suggestions and correspondence concerning further development of the Recommendations to the Chairman of AK 2.1 (see Imprint for address).

Hamburg, 2012

Hans-Georg Kempfert

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1 Introduction to the Recommendations and their Application Principles

1.1 National and International Regulations for Piling Works

(1) Since the implementation of DIN EN 1997-1:2009-09: Eurocode 7: Geotechnical Design – Part 1: General Rules, pile analysis and design in Germany is governed by

- Section 7 of Eurocode EC 7-1 (Eurocode 7), in conjunction with
- DIN 1054:2010-12: Subsoil – Verification of the Safety of Earthworks and Foundations – Supplementary Rules to the German version DIN EN 1997-1, and the
- National Annex to EC 7-1, namely DIN EN 1997-1/NA:2010-12: National Annex – Nationally Determined Parameters – Eurocode 7: Geotechnical Design – Part 1: General Rules.

These three coordinated documents are summarised in the German Eurocode 7 Handbook, Volume 1 [44].

Note: In case amendments or corrections are made to the standards included in the German Eurocode 7 Handbook, Volume 1 [44], the changes must be adopted even when not yet incorporated in [44].

(2) In addition, the individual pile systems are governed by the following execution standards:

- | | |
|-----------------|---|
| DIN EN 1536: | Execution of special geotechnical works – Bored piles. |
| DIN SPEC 18140: | Supplementary provisions to DIN EN 1536. |
| DIN EN 12699: | Execution of special geotechnical works – Displacement piles. |
| DIN SPEC 18538: | Supplementary provisions to DIN EN 12699. |
| DIN EN 14199: | Execution of special geotechnical works – Micropiles. |
| DIN SPEC 18539: | Supplementary provisions to DIN EN 14199. |
| DIN EN 12794: | Precast concrete products – Foundation piles. |
| DIN EN 1993-5: | Design of steel structures – Part 5: Piling. |

(3) Because diaphragm wall elements are often employed in the same way as pile foundations, the respective execution standard must also be considered:

- | | |
|--------------|---|
| DIN EN 1538: | Execution of special geotechnical works – Diaphragm walls |
|--------------|---|

in conjunction with:

- | | |
|-----------|--|
| DIN 4126: | Stability analysis of diaphragm walls. |
|-----------|--|

(4) In addition, several ISO standards are being compiled for a number of special topics relating to piles. They are however not likely to be implemented as building regulations in Germany. Currently, these include:

DIN EN ISO 22477-1: Geotechnical investigation and testing – Testing of geotechnical structures – Part 1: Pile load test by static axially loaded compression.

On a national basis, the regulations in Section 9 should be adopted for static pile testing.

1.2 Types of Analysis and Limit States using the Partial Safety Factor Approach

1.2.1 New standards generation and their application to pile foundations

(1) By European Commission decision national building design and execution standards either already have been or will in future be replaced by European standards. Actually numerous European standards have been published for geotechnical design and execution of special geotechnical works.

(2) The European standards governing pile execution are listed in 1.1.

(3) Analysis and design of pile foundations is dealt with in the European standard DIN EN 1997-1: Geotechnical Design (Eurocode 7) in conjunction with DIN 1054 and DIN EN 1997-1/NA, see 1.1. These three standards were implemented by the German Building Authorities for use in Germany as of 01.07.2012.

(4) Until the time of implementation of the Eurocodes as binding building regulations a new generation of national standards using the partial safety factor approach served as temporary solution for all fields of structural engineering. The following standards in particular represented the governing standards for pile foundations:

DIN 1055-100:2001-03: Basis of structural design;

DIN 1054:2005-01: Verification of the safety of earthworks and foundations;

DIN 18800:1990-11: Steel structures and;

DIN 1045-2:2001-07: Concrete, reinforced and prestressed concrete structures – Part 2: Concrete – Specification, properties, production and conformity – Application rules for DIN EN 206-1.

(5) These Recommendations on Piling (EA-Pfähle) are based on the standards listed in 1.1 above and, for design in particular, on Eurocode EC 7-1, in conjunction with DIN 1054 and the NA as stipulated in 1.1 (1).