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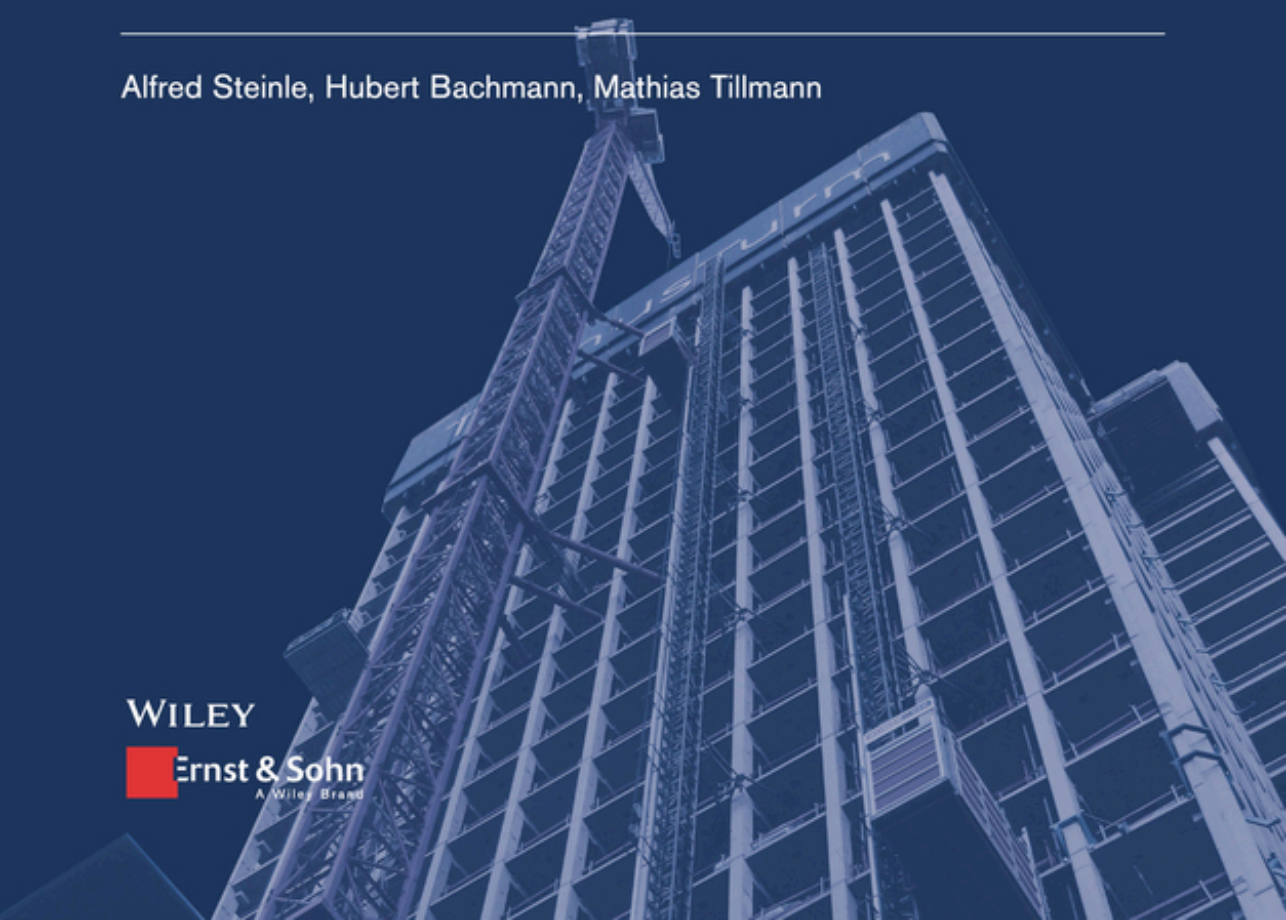
Precast Concrete Structures

Alfred Steinle, Hubert Bachmann, Mathias Tillmann



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Alfred Steinle
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Second Edition

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In memory of
Dr.- Ing. Alfred Steinle
(1936–2017)
In the many years that we worked together,
he was always an esteemed partner and colleague.

Foreword

The *Concrete Yearbook* is a very important source of information for engineers involved in the planning, design, analysis, and construction of concrete structures. It is published on a yearly basis and offers chapters devoted to various, highly topical subjects. Every chapter provides extensive, up-to-date information written by renowned experts in the areas concerned. The subjects change every year and may return in later years for an updated treatment. This publication strategy guarantees that not only is the latest knowledge presented, but that the choice of topics itself meets readers' demands for up-to-date news.

For decades, the themes chosen have been treated in such a way that, on the one hand, the reader gets background information and, on the other, becomes familiar with the practical experience, methods, and rules needed to put this knowledge into practice. For practising engineers, this is an optimum combination. In order to find adequate solutions for the wide scope of everyday or special problems, engineering practice requires knowledge of the rules and recommendations as well as an understanding of the theories or assumptions behind them.

During the history of the *Concrete Yearbook*, an interesting development has taken place. In the early editions, themes of interest were chosen on an ad hoc basis. Meanwhile, however, the building industry has gone through a remarkable evolution. Whereas in the past attention focused predominantly on matters concerning structural safety and serviceability, nowadays there is an increasing awareness of our responsibility with regard to society in a broader sense. This is reflected, for example, in the wish to avoid problems related to the limited durability of structures. Expensive repairs to structures have been, and unfortunately still are, necessary because in the past our awareness of the deterioration processes affecting concrete and reinforcing steel was inadequate. Therefore, structural design should now focus on building structures with sufficient reliability and serviceability for a specified period of time, without substantial maintenance costs. Moreover, we are confronted by a legacy of older structures that must be assessed with regard to their suitability to carry safely the increased loads often applied to them today. In this respect, several aspects of structural engineering have to be considered in an interrelated way, such as risk, functionality, serviceability, deterioration processes, strengthening techniques, monitoring, dismantlement, adaptability and recycling of structures, and structural materials plus the introduction of modern high-performance materials. The significance of sustainability has also been recognised. This must be added to the awareness that

design should focus not just on individual structures and their service lives, but on their function in a wider context as well, i.e. harmony with their environment, acceptance by society, responsible use of resources, low energy consumption, and economy. Construction processes must also become cleaner and cause less environmental impact and pollution.

The editors of the *Concrete Yearbook* have clearly recognised these and other trends and now offer a selection of coherent subjects that reside under the common 'umbrella' of a broader societal development of great relevance. In order to be able to cope with the corresponding challenges, the reader can find information on progress in technology, theoretical methods, new research findings, new ideas on design and construction, developments in production and assessment and conservation strategies. The current selection of topics and the way they are treated makes the *Concrete Yearbook* a splendid opportunity for engineers to find out about and stay abreast of developments in engineering knowledge, practical experience and concepts in the field of the design of concrete structures on an international level.

TU Delft

Prof. Dr. Ir. Dr.-Ing. h. c. Joost Walraven
Honorary president of the international concrete federation fib

Preface to the Third German Edition

Building with precast concrete components is as old as building with reinforced concrete itself, for the very first reinforced concrete element, Joseph Monier's flower tub (c. 1850), was, in essence, a *precast* concrete item.

It was only in the second half of the twentieth century, however, that this form of construction took on its industrialised form. Factors that contributed to this were, in particular, the development of heavy lifting equipment, the use of mechanised steel moulds, and, more recently, automated manufacturing systems, for producing suspended floor elements especially.

This book on precast concrete construction is based on the manuscript written by Prof. Dr.-Ing. Volker Hahn (former director of Ed. Züblin AG) for his lectures at the University of Stuttgart in the early 1970s, which was recast as a book by Dr.-Ing. Alfred Steinle. The manuscript rewritten by Alfred Steinle and Volker Hahn first appeared in *Beton-Kalender 1988*. That article was reprinted in 1995 and in revised form in 2009 and 2016. It was in 1998 that the information first appeared as an actual book as part of the *Bauingenieur-Praxis* series. The second edition was published in 2009 and now it is time for a new edition.

With modern methods of construction making use of industrial methods of manufacture, which includes construction with factory-precast concrete components, the design of the individual elements, and also the entire structure, is heavily influenced by the factory production. On the manufacturing side, the growing trend towards mechanisation and automation in production is evident.

The development of high-performance concretes provides us with the chance to employ these for precast concrete construction in particular because factory production presents excellent conditions for their use. The first precast concrete components made from ultrahigh-strength concrete for bridges and façades are already in use, the latter also making use of glass fibres or carbon inlays. Besides the industrial production of batches and series of components, we are seeing more and more one-offs being produced, which take advantage of the excellent production options in order to achieve a high standard of quality. These tendencies will become even more obvious as more and more progress is made in the development of concrete as a building material.

The authors' aim in writing this book is to map out the boundary conditions of factory prefabrication for architects and structural engineers and also to demonstrate the opportunities presented by this method of construction – and thus contribute to the ongoing development of precast concrete structures.

November 2018

Alfred Steinle, Hubert Bachmann,
Mathias Tillmann
Stuttgart/Bonn

About the Authors

Alfred Steinle (1936–2017) turned the lecture notes of Prof. Dr.-Ing. Volker Hahn, which dated from the early 1970s, into a manuscript that became the starting point for this book. After a number of years in bridge-building, Alfred Steinle also became heavily involved in precast concrete construction at Züblin. His theoretical work covered bridge-building with torsion and section deformations in box-girder bridges and in precast concrete structures within the scope of the 6M system with corbels, notched beam ends, and pocket foundations. In addition, he was a key figure in many precast concrete projects such as the 6M schools, the University of Riyadh, schools with foamed concrete wall panels in Iraq, Züblin House, and the construction of a modern automated precasting plant. Alfred Steinle retired in 1999 and by that time he had risen to the post of authorised signatory in the engineering office at Züblin's head office.

Hubert Bachmann (b. 1959) began his career in a precasting plant in 1976 as an apprentice for concrete and precast concrete construction. After studying structural engineering and completing his doctorate at the University of Karlsruhe, he accepted a post in the structural engineering office of Ed. Züblin AG in Stuttgart in 1993, where he has worked ever since. His duties have included the detailed design of structures of all kinds plus research and development in the civil and structural engineering sectors. He has been presenting the series of Hahn lectures on precast concrete structures at the University of Stuttgart since 2003.

Mathias Tillmann (b. 1970) has been an engineering and standards consultant at Fachvereinigung Deutscher Betonfertigteilbau e.V. (FDB) since 2007 and technical director since 2008. He specialised in structural engineering during his studies at RWTH Aachen University. After attaining his diploma, he worked as a project engineer, structural engineer, and designer. Mathias Tillmann has written numerous brochures, advisory documents, and specialist articles on the subject of precast concrete.

All three authors have been or still are very much involved in construction industry organisations, many technical boards and national and international standards committees concerned with precast concrete construction.

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Introduction

This book first appeared as an article written by Alfred Steinle and Volker Hahn for the 1988 edition of the *Beton-Kalender*. It was reprinted in *Beton-Kalender 1995* and then published as a book in the *Bauingenieur-Praxis* series in 1998. Hubert Bachmann, Alfred Steinle and Volker Hahn updated the information for publication in *Beton-Kalender 2009* and this appeared as a new edition of the book in the *Bauingenieur-Praxis* series in 2010. Alfred Steinle, Hubert Bachmann, and Mathias Tillmann reconceived and completely revised the content for *Beton-Kalender 2016*, and it is that version that has again been published as a separate book, the third German edition, as part of the *Bauingenieur-Praxis BiP* series.

The first chapter looks at general aspects of precast concrete construction, its history and the status of European standardisation. The economic use of precast concrete elements is only possible when the design is carried out to suit the production and erection of such elements. Therefore, the second chapter deals with the design of precast concrete structures. Besides outlining the boundary conditions that must be observed when designing for precast concrete, the authors present a number of typical precast concrete designs.

Special attention must be paid to the connections between precast concrete elements, because these are the weak points – for horizontal loads in particular. The stability of precast concrete structures is therefore described in detail in Chapter 3. In particular, owing to the need to check critical details, proper yet simplified engineering assessments are to be preferred to computer calculations when considering stability. Chapters 4 and 5 deal with the various components of precast concrete production and the connections between those components. Specific design issues are examined in detail in Chapter 6.

Façades are becoming an increasingly important application for precast concrete elements. Chapter 7 is therefore dedicated to this topic. And it is façades in particular that are making use of new types of concrete and reinforcement. The final chapter looks at the actual manufacture of precast concrete elements so that the reader gains a full understanding of this form of construction taking into account the needs of production.

New types of concrete, new types of reinforcement, new methods of production – precast concrete construction is the chief proving ground for new developments and applications. Precast concrete therefore represent one of the

Precast Concrete Structures, Second Edition. Alfred Steinle, Hubert Bachmann, and Mathias Tillmann.

most innovative forms of construction, a fact that is reflected in its growing popularity.

Although this book focuses on precast concrete from the point of view of the building industry and the authors concentrate mainly on buildings in general, it should not go unmentioned that precast concrete construction has been able to win considerable market shares in many other construction sectors through the development of economic yet bespoke solutions. Examples of these are bridges, tunnel linings, pipes, pipe bridges, towers, masts, piles, detached homes, prefabricated basements, retaining walls, room modules, prefabricated garages, noise barriers, railway sleepers, guided bus tracks, agricultural buildings, ballastless tracks, cooling tower trickle fill structures, etc. The reader is referred to the specialist literature dealing with these specialist areas. This book also only describes structural or architectural precast concrete elements for buildings and structures and not 'concrete products', i.e. small-format components manufactured and stocked in great numbers and available from trade outlets, e.g. sewage pipes, paving stones, etc.

The references at the end of each chapter have been completely recompiled and in the main contain publications of recent years. Older publications have only been retained when they illustrate potential solutions to fundamental problems that still remain valid today. In this context, the reader is referred to the earlier articles with the same title in the *Beton-Kalender* yearbooks of 1988, 1995, and 2009 [1–3]. References to the general literature on reinforced concrete construction have been omitted and the reader is referred to the corresponding articles in the *Beton-Kalender*, unless they concern areas that also touch on the specific problems of precast concrete construction.

In particular, readers should consult the publications of the Fachvereinigung Deutscher Betonfertigteilbau e.V. (FDB, German Association for Precast Concrete Construction), e.g. [4, 5], and Bindseil [6]. Furthermore, the *fib* manual also covers international developments in the field of precast concrete construction [7]. The *Beton- und Fertigteil-Jahrbuch* [8], now published under the title of *Betonbauteile*, regularly includes chapters on structural precast concrete elements and precast concrete architecture in addition to small-format concrete products.

The national, European and international standards that concern precast concrete construction are listed below (position as of July 2017). The list also contains the relevant publications of the Deutscher Ausschuss für Stahlbeton (DAfStb, German Committee for Structural Concrete), the FDB, and the Deutscher Beton- und Bautechnik-Verein e.V. (DBV, German Society for Concrete and Construction Technology). This list does not claim to be exhaustive. Other regulations and codes of practice can be found in the lists at the end of each chapter.

National standards (some available in English)

DIN 488 Reinforcing steels

Part 1:2009-08 Grades, properties, marking

Part 2:2009-08 Reinforcing steel bars

Part 3:2009-08 Reinforcing steel in coils, steel wire

Part 4:2009-08 Welded fabric

Part 5:2009-08 Lattice girders

Part 6:2010-01 Assessment of conformity

DIN 1045 Concrete, reinforced and prestressed concrete structures

Part 1:2008-08 Design and construction (*withdrawn*)

Part 2:2008-08 Concrete – Specification, properties, production and conformity – Application rules for DIN EN 206-1

Part 3:2012-03 Execution of structures – Application rules for DIN EN 13670, with corrigendum 1:2013-07

Part 4:2012-02 Additional rules for the production and the conformity of prefabricated elements

DIN 1048 Testing concrete

Part 1:1991-06 Testing of fresh concrete (*withdrawn*)

Part 2:1991-06 Testing of hardened concrete (specimens taken in situ) (*withdrawn*)

Part 4:1991-06 Determination of the compressive strength of hardened concrete in structures and components; application of reference lines and evaluation with special methods (*withdrawn*)

Part 5:1991-06 Testing of hardened concrete (specimens prepared in mould) (*withdrawn*)

DIN 1054:2010-12 Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1, with amendments A1:2012-08 and A2:2015-11

DIN 1164 Special cement

Part 10:2013-03 Composition, requirements and conformity evaluation for cement with low effective alkali content

Part 11:2003-11 Composition, specification and conformity evaluation for cement with short setting time

Part 12:2005-06 Composition, specification and conformity evaluation for cement with higher quantity of organic constituents

DIN 4030 Assessment of water, soil and gases for their aggressiveness to concrete

Part 1:2008-06 Principles and limiting values

Part 2:2008-06 Sampling and analysis of water and soil samples

DIN 4102 Fire behaviour of building materials and building components

Part 1:1998-05 Building materials; concepts, requirements and tests

Part 2:1977-09 Building components; definitions, requirements and tests

Part 3:1977-09 Fire walls and non-loadbearing external walls; definitions, requirements and tests

Part 4:2016-05 Synopsis and application of classified building materials, components and special components

Part 16:2015-09 'Brandschacht' tests

DIN 4108 Thermal insulation and energy economy in buildings

Supplement 2:2006-03 Thermal bridges – Examples for planning and performance

Part 2:2013-02 Minimum requirements (for) thermal insulation

Part 3:2014-11 Protection against moisture subject to climate conditions; requirements and directions for design and construction

Part 4:2017-03 Hygrothermal design values

Part 6:2003-06 (*pre-standard*) Calculation of annual heat and energy use, with corrigendum 1:2004-03

Part 7:2011-01 Airtightness of buildings – Requirements, recommendations and examples for planning and performance

Part 10:2015-12 Application-related requirements for thermal insulation materials – Factory-made products

Part 11:2016-04 (*draft*) Minimum requirements (for) the durability of bond strength with adhesive tapes and adhesive masses for the establishment of airtight layers

DIN 4109 Sound insulation in buildings

Part 1:2016-07 Minimum requirements, with amendment A1:2017-01

Part 2:2016-07 Verification of compliance with the requirements by calculation, with amendment A1:2017-01

Part 4:2016-07 Testing of acoustics in buildings

Part 31:2016-07 Data for verification of sound insulation (component catalogue) – Framework document

Part 32:2016-07 Data for verification of sound insulation (component catalogue) – Solid construction

Supplement 2:1989-11 Guidelines for planning and execution; proposals for increased sound insulation; recommendations for sound insulation in personal living and working areas

Supplement 3:1996-06 Calculation of $R'_{w,R}$ for assessing suitability as defined in DIN 4109 on the basis of the sound reduction index R_w determined in laboratory tests

DIN 4141-13:2010-07 Structural bearings – Part 13: Guide bearings with sliding surfaces steel to steel – Design and manufacture

DIN 4149:2005-04 Buildings in German earthquake areas – Design loads, analysis and structural design of buildings (*withdrawn from DIN catalogue, but still considered by building authorities*)

DIN 4226-100:2002-02 Aggregates for concrete and mortar – Part 100: Recycled aggregates

DIN 4226-101:2016-09 (*draft*) Recycled aggregates for concrete in accordance with DIN EN 12620 – Part 101: Types and regulated dangerous substances

DIN 4226-102:2016-09 (*draft*) Recycled aggregates for concrete in accordance with DIN EN 12620 – Part 102: Type testing and factory production control

DIN 11622 Silage and liquid manure containers, containers in biogas plants, bunker silos and trench silos

Supplement 1:2006-01Explanatory notes, diagrams to illustrate the design of the base/wall joint (*withdrawn*)

Part 1:2006-01 Design principles; general requirements (*withdrawn*)

Part 2:2015-09 Silage and liquid manure containers and containers in biogas plants made of concrete

Part 5:2015-09 Bunker silos and trench silos

Part 22:2015-09 Concrete blocks acting as (permanent) formwork for silage and liquid manure containers, bunker silos and trench silos and liquid manure channels

DIN V 18004:2004-04 (*pre-standard*) Use of building products in construction works – Test methods for aggregates according to DIN V 20000-103 and DIN V 20000-104

DIN 18065:2015-03 Stairs in buildings – Terminology, measuring rules, main dimensions

DIN 18195:2017-07 Waterproofing of buildings – Vocabulary

DIN 18197:2017-04 (*draft*) Sealing of joints in concrete with waterstops

DIN 18200:2000-05 Assessment of conformity for construction products – Factory production control, third-party monitoring and certification

DIN 18202:2013-04 Tolerances in building construction – Buildings

DIN 18203-1:1997-04 Tolerances in building construction – Part 1: Prefabricated components made of concrete, reinforced concrete and prestressed concrete (*withdrawn*)

DIN V 18500:2006-12 Cast stones – Terminology, requirements, testing, inspection

DIN 18516 Cladding for external walls, ventilated at rear

Part 1:2010-06 Requirements, principles of testing

Part 5:2013-09 (Cast) stone; requirements, design

DIN 18531 Waterproofing of roofs, balconies and walkways

Part 1:2017-07 Non-utilised and utilised roofs – Requirements and principles for execution and design

Part 2:2017-07 Non-utilised and utilised roofs – Materials

Part 3:2017-07 Non-utilised and utilised roofs – Selection, execution and detailing

Part 4:2017-07 Non-utilised and utilised roofs – Maintenance

Part 5:2017-07 Balconies and walkways

DIN 18532 Waterproofing of concrete areas (for vehicular traffic)

Part 1:2017-07 Requirements and principles for design and execution

Part 2:2017-07 Waterproofing with composite sheeting comprising a single welded polymerised bitumen sheet and a mastic asphalt waterproofing layer

Part 3:2017-07 Waterproofing comprising two layers of polymerised bitumen sheeting

Part 4:2017-07 Waterproofing comprising a single layer of synthetic or elastomer sheeting

Part 5:2017-07 Waterproofing comprising a layer of polymerised bitumen sheet in conjunction with a single synthetic or elastomer sheeting

Part 6:2017-07 Waterproofing with liquid-applied waterproofing materials

DIN 18533 Waterproofing of elements in contact with soil

Part 1:2017-07 Requirements and principles for design and execution

Part 2:2017-07 Waterproofing with waterproofing materials in sheet form

Part 3:2017-07 Waterproofing with liquid-applied waterproofing materials

DIN 18540:2014-09 Sealing of exterior wall joints in buildings using joint sealants

DIN 18542:2009-07 Sealing of outside wall joints with impregnated sealing tapes made of cellular plastics – Impregnated sealing tapes – Requirements and testing

DIN V 20000 (*pre-standard*) Application of construction products in structures

Part 120:2006-04 Application rules for DIN EN 13369

Part 125:2006-12 Rules for the application of precast concrete garages according to DIN EN 13978-1

DIN 51043:1979-08 Trass; requirements, tests

European standards

DIN EN 196 Methods of testing cement

Part 1:2016-11 Determination of strength

Part 2:2013-10 Chemical analysis of cement

Part 3:2017-03 Determination of setting times and soundness

Part 5:2011-06 Pozzolanicity test for pozzolanic cement

Part 6:2017-05 (*draft*) Determination of fineness

Part 7:2008-02 Methods of taking and preparing samples of cement

Part 8:2010-07 Heat of hydration – Solution method

Part 9:2010-07 Heat of hydration – Semi-adiabatic method

Part 10:2006-10 Determination of the water-soluble chromium(VI) content of cement

DIN EN 197 Cement

Part 1:2014-07 (*draft*) Composition, specifications and conformity criteria for common cements

Part 1:2011-11 Composition, specifications and conformity criteria for common cements

Part 2:2014-05 Conformity evaluation

DIN EN 206-1:2001-07 Concrete – Specification, performance, production and conformity, with amendments A1:2004-10 and A2:2005-09

DIN EN 206:2017-01 Concrete – Specification, performance, production and conformity (*not approved by German building authorities*)

DIN EN 450 Fly ash for concrete

Part 1:2012-10 Definition, specifications and conformity criteria

Part 2:2005-05 Conformity evaluation

DIN EN 933 Tests for geometrical properties of aggregates

Part 1:2012-03 Determination of particle size distribution – Sieving method

Part 2:1996-01 Determination of particle size distribution; test sieves, nominal size of apertures

Part 3:2012-04 Determination of particle shape – Flakiness index

Part 4:2015-01 Determination of particle shape – Shape index

Part 5:2005-02 Determination of percentage of crushed and broken surfaces in coarse aggregate particles

Part 6:2014-07 Assessment of surface characteristics – Flow coefficient of aggregates

Part 7:1998-05 Determination of shell content; percentage of shells in coarse aggregates

Part 8:2015-07 Assessment of fines – Sand equivalent test

Part 9:2013-07 Assessment of fines – Methylene blue test

Part 10:2009-10 Assessment of fines – Grading of filler aggregates (air-jet sieving)

Part 11:2011-05 Classification test for the constituents of coarse recycled aggregate

DIN EN 934 Admixtures for concrete, mortar and grout

Part 1:2008-04 Common requirements

Part 2:2014-11 (*draft*) Concrete admixtures – Definitions, requirements, conformity, marking and labelling

Part 2:2012-08 Concrete admixtures – Definitions, requirements, conformity, marking and labelling

Part 3:2012-09 Admixtures for masonry mortar – Definitions, requirements, conformity and marking and labelling

Part 4:2009-09 Admixtures for grout for prestressing tendons – Definitions, requirements, conformity, marking and labelling

Part 5:2008-02 Admixtures for sprayed concrete – Definitions, requirements, conformity, marking and labelling

Part 6:2017-02 (*draft*) Sampling, assessment and verification of the constancy of performance

Part 6:2006-03 Sampling, conformity control and evaluation of conformity

DIN EN 1008:2002-10 Mixing water for concrete – Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete

DIN EN 1090 Execution of steel structures and aluminium structures

Part 1:2012-02 Requirements for conformity assessment of structural components

Part 2:2016-12 (*draft*) Technical requirements for steel structures

Part 2:2011-10 Technical requirements for steel structures

Part 3:2017-03 Technical requirements for aluminium structures

Part 3:2008-09 Technical requirements for aluminium structures

Part 4:2015-11 (*draft*) Technical requirements for cold-formed structural steel elements and cold-formed structures for roof, (suspended) floor and wall applications

Part 5:2017-07 Technical requirements for cold-formed structural aluminium elements and cold-formed structures for roof, (suspended) floor and wall applications

DIN EN 1097 Tests for mechanical and physical properties of aggregates

Part 1:2011-04 Determination of the resistance to wear (micro-Deval)

Part 2:2016-07 (*draft*) Methods for the determination of resistance to fragmentation

Part 2:2010-07 Methods for the determination of resistance to fragmentation

Part 3:1998-06 Determination of loose bulk density and voids

Part 4:2008-06 Determination of the voids of dry compacted filler

Part 5:2008-06 Determination of the water content by drying in a ventilated oven, with corrigendum 1:2008-09

Part 6:2013-09 Determination of particle density and water absorption

Part 7:2008-06 Determination of the particle density of filler – Pyknometer method, with corrigendum 1:2008-09

Part 8:2016-07 (*draft*) Determination of the polished stone value

Part 8:2009-10 Determination of the polished stone value

Part 9:2014-03 Determination of the resistance to wear by abrasion from studded tyres – Nordic test

Part 10:2014-09 Determination of water suction height

Part 11:2013-11 Determination of compressibility and confined compressive strength of lightweight aggregates

DIN EN 1168:2011-12 Precast concrete products – Hollow-core slabs

DIN EN 1337 Structural bearings

Part 1:2001-02 General design rules

Part 2:2004-07 Sliding elements

Part 3:2005-07 Elastomeric bearings

Part 4:2004-08 Roller bearings

Part 5:2005-07 Pot bearings

Part 6:2004-08 Rocker bearings

Part 7:2004-08 Spherical and cylindrical PTFE bearings

Part 8:2008-01 Guide bearings and restraint bearings

Part 9:1998-04 Protection

Part 10:2003-11 Inspection and maintenance

Part 11:1998-04 Transport, storage and installation

DIN EN 1793 Road traffic noise-reducing devices – Test method for determining the acoustic performance

Part 1:2017-07 Intrinsic characteristics of sound absorption under diffuse sound field conditions

Part 2:2017-01 (*draft*) Intrinsic characteristics of airborne sound insulation under diffuse sound field conditions

Part 2:2013-04 Intrinsic characteristics of airborne sound insulation

Part 3:1997-11 Normalised traffic noise spectrum

Part 4:2015-05 Intrinsic characteristics – In situ values of sound diffraction

Part 5:2016-10 Intrinsic characteristics – In situ values of sound reflection under direct sound field conditions

Part 6:2017-01 (*draft*) Intrinsic characteristics – In situ values of airborne sound insulation under direct sound field conditions

Part 6:2013-04 Intrinsic characteristics – In situ values of airborne sound insulation under direct sound field conditions

DIN EN 1794 Road traffic noise-reducing devices – Non-acoustic performance

Part 1:2016-08 (*draft*) Mechanical performance and stability requirements

Part 1:2011-04 Mechanical performance and stability requirements

Part 2:2011-04 General safety and environmental requirements

Part 3:2014-04 Reaction to fire – Burning behaviour of noise reducing devices and classification

DIN EN 1990:2010-12 Eurocode: Basis of structural design, including DIN EN 1990/NA:2010-12, national annex, with DIN EN 1990/NA/A1:2012-08

DIN EN 1991 Eurocode 1: Actions on structures

Part 1:2010-12 General actions – Densities, self-weight, imposed loads for buildings, including DIN EN 1991-1-1/NA:2010-12, national annex – Nationally determined parameters, with amendment A1:2015-05

Part 1:2-2010 General actions – Actions on structures exposed to fire, with corrigendum 1:2013-08, including DIN EN 1991-1-2/NA:2015-09, national annex – Nationally determined parameters

Part 1:3-2010 General actions – Snow loads, with amendment A1:2015-12, including DIN EN 1991-1-3/NA:2010-12, national annex – Nationally determined parameters