

Concrete and Sustainability

混凝土与可持续发展

[挪威] Per Jahren

[中国] Tongbo Su



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Chemical Industry Press



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[挪威] Per Jahren (珀·雅润) 著
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回顾混凝土与建筑发展的历程，作者关注并提出了如下的焦点问题及其演变方向：

安全性→耐久性→服役性/功能性→可持续性

本书全面分析了世界混凝土可持续发展所面临挑战的复杂性和应对方案的多样性。第一章主要从混凝土对社会与经济发展的作用和影响的角度对混凝土可持续性问题进行了探讨；第二章重点介绍国际范围内混凝土可持续发展所涉及的环境评价工具和方法论，并分析了不同的关注焦点、评价方法和时限对混凝土可持续性的影响；第三、四章着重分析了水泥混凝土领域所面临的排放、捕集与吸收和循环的挑战；第五章分析了其他方面的环境挑战；第六、七章给出了综合评述及未来发展趋势的分析；最后列出了500多条参考文献，以供有兴趣的读者深度查阅。

本书主要探讨在全球范围内提升混凝土可持续性的系统思考方法和技术途径，以此鼓励和帮助有兴趣的读者（包括政策制定者，建筑与材料领域的专家、工程师，高等学校的教授、学生，以及致力于环境与可持续发展领域的人员等）针对混凝土可持续发展所面临的问题，用系统方法论对其资源可获取性、技术与经济可行性、环境相容性以及社会责任等要素进行全方位的思考和行动。

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Foreword

By V. Mohan Malhotra

The International Panel on Climate Change (IPCC), made up of 600 scientists from 40 countries, in a landmark report in February 2007, laid to rest any doubts about global warming. According to the IPCC, global warming is here, is primarily due to human activity, and is irreversible. In fact, global warming is the most serious sustainability issue confronting the global community today. The principal sources of global warming are CO₂ emissions, and if no action is taken to curb CO₂ emissions, it is most likely that the earth's average temperature could increase by 4°C by the end of this century, greatly impacting food production, water availability, and extreme weather events worldwide. The recent Super Storm Sandy in the United States is one such example. The damage caused by this storm is estimated to exceed 50 billion USD. The principal CO₂-emitting sectors of the economy include coal-powered plants, transportation, and major industries such as steel, cement, and concrete.

The production of 1 tonne of Portland cement clinker, the main component of modern hydraulic cements, is accompanied by the direct release of approximately 1 tonne of CO₂. Therefore, considerable CO₂ emissions are attributable to the global production of more than 3 billion tonnes of cement, the binder component of concrete.

There are several publications available that discuss the sustainability issues related to the production of Portland cement, but this is the first book that covers comprehensively the sustainable issues concerning the aggregate cement and concrete industry.

The authors, Mr. Per Jahren of Norway and Professor Tongbo Sui of China, are world-renowned engineers and concrete technologists. Their vast experience in cement and concrete is evident in their research of the sustainable issues concerning the concrete industry. They have skillfully addressed the issues of recycling of concrete and water shortages, which are the next crises on the horizon. Such distant topics as radiation and building materials are also discussed. The wealth of information on

sustainability and the concrete industry brought together in this book is remarkable, and the authors' efforts are to be commended. All those interested in the concrete industry and sustainability will find this book very informative and of immense value.

Dr. V. Mohan Malhotra

*Recipient of the 2012 Sustainability Award of the
American Concrete Institute*

*Recipient of the 2007 Sustainability Award of the
Norwegian Concrete Institute*

*Recipient of the 2006 Lifetime Achievement Award of the
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Fellow, Canadian Society of Civil Engineers

Fellow, Engineering Institute of Canada

Foreword

By Wei Sun

Sustainability has increasingly become the global solution in the 21st century to combating the challenges of climate change and natural resources depletion the world is facing. The cement industry, as one of the key fundamental materials industries, on the one hand plays a very important role in social and economic development, and, on the other, may also impose great challenge in terms of its large consumption of natural resources and energy and the emissions of greenhouse gases. This issue is of great importance, especially for China, as the world's largest cement and concrete producer and consumer, accounting for more than half of the world's cement production.

Concrete and Sustainability presents to the readers a holistic view and approach as well as worldwide thinking and methodologies covering the levels of safety, durability, functionality and economical feasibility, environmental compatibility, and social responsibility to addressing the sustainability issues. The wide spectrum of possible solutions given in this book provides a way to understand and deal with these global issues. In this context, there is no doubt that this is the first book of its kind, introducing not only technological solutions, but also methodologies and a way of thinking as a whole.

The author, Mr. Per Jähren, is a famous concrete specialist, and has enthusiastically participated in many cement and concrete conferences and seminars in China within the last 10 years, sharing his experience and skills, which are of great value to his Chinese colleagues. His coauthor, Prof. Tongbo Sui, is a leading scientist in the chemistry of cement and concrete, and is dedicated to the R&D of low energy and low CO₂ emission and advanced cement-based materials, with remarkable gains achieved in the development and application of belite-based cements.

This highly informative book, based on the knowledge and experience of the authors, will hopefully be of great benefit to researchers, engineers, architects, university students, and decision makers.

Dr. Wei Sun

*Member of the Chinese Academy of Engineering
Professor of Southeast University, China*

Preface

In light of the development of world concrete and construction, we see an evolution in the focus and direction of

Safety → Durability → Serviceability/Functionality → Sustainability

It is important in this context to learn at least two things:

- All the components in the evolution process are closely linked to each other and function upon need instead of occurring and existing independently or replacing one by another.
- The latest developed component, sustainability, has not only evolved from the previous components, but works as a function of them as well.

We therefore believe that sustainability is not only an environmental issue, but is indeed a holistic thinking/approach that can be considered the function of safety, durability, functionality and economical feasibility, environmental compatibility, and social responsibility. The level and magnitude of each component to sustainability varies depending on the specific requirement of the target and local boundary conditions.

We have, over recent decades, seen a growing worldwide concern and understanding of sustainability issues, not only in society in general, but also in the cement and concrete industry. The increased focus on climate change has definitely been an important catalyst in this process. There is hardly any doubt about the importance of greenhouse gas emission and the negative effects of climate change. However, sustainable development and environmental issues are much more than this.

This book tries to provide readers with the widest possible views on the sustainability issues of concrete, the world's largest construction material, the complexity of the challenges from different angles, and the versatility and possibilities of solutions to address these challenges. It is a methodologically technical book on concrete and sustainability, rather than only a concrete scientific book, to encourage the readers to think, understand, and

reconsider the discussed topic and solutions that might be taken in a holistic way in terms of resource availability, technical viability, economical feasibility, and environmental compatibility. The intention has not been to give technical details on sustainable issues, but to show some of the manifold versatility in the sustainability efforts that have taken place in the concrete environment around the world. Hopefully, we have been able to offer some ideas to concrete technologists or enthusiasts in their efforts to find sustainable solutions.

In Chapter 1, we explore the sustainability issue of concrete from a social and economic perspective. Chapter 2 gives an introduction into the various rules and regulations that the concrete environment is facing in society. Chapters 2 through 4 are about the various environmental challenges that the cement and concrete industry is facing. As emissions, absorptions, and recycling have been the most central elements in discussions in the cement and concrete environment so far, these topics have their own chapters. All the other issues are treated in alphabetical order in Chapter 5. When we say “all the other issues,” we are aware that other listings are possible. We have chosen to use the issues that have been used in the Norwegian environmental database since 2002. Experience has shown that the importance of the various issues changes with the various platforms in the industry and society. We therefore treat the issues in alphabetical order instead of importance or significant sequence. In Chapters 6 and 7, we have provided some comments about future development. Finally, a comprehensive reference list, with some 500 references given in the book, might be of help to readers who want to obtain more technical details.

Per Jahren

President of P. J. Consult AS

Former president and honor member of the Norwegian Concrete Society

Tongbo Sui

Ph D, Professor

Director General of Sinoma Research Institute

Vice President of China Sinoma International Engineering Co.Ltd

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The authors



Picture of the authors Per Jahren (left) and Tongbo Sui (right) took on June 29, 2013 in Oslo, Norway before the model of artificial fish reef components designed by Per Jahren. Information about the project has been detailed in 5.9.5.7 The Tjuvholmen project.

Per Jahren is semi-retired and has, in later years, concentrated most of his time on writing.

In 2011, the book *Concrete—History and Accounts* was published in Norwegian and English, and, in 2012, the book *Concrete—Manifold and Possibilities* in Norwegian.

Per Jahren was born in Oslo, Norway in 1939, and, after primary school and college, served his military service in the engineer core. His civil engineering education was in England and Norway, receiving a master's degree in civil engineering with concrete as a major in 1965, from the Norwegian

Technical University in Trondheim. He later earned a business degree from Norway and Stanford University in the United States.

Through his nearly 50-year professional career he has been involved in cement and concrete—design, production, marketing, and development work in consulting companies, precast concrete production, cement production, and admixture and materials production and marketing. Since 1986, he has been involved in his own company, P.J. Consult AS in Asker, Norway.

Per Jahren became interested in environmental issues in the cement and concrete industry in his career and gave his first paper on the topic well over 30 years ago.

He was editor of the Norwegian environmental database for concrete, www.miljobasen.no, and chairman of the environmental committee of the Norwegian Concrete Society from 2002 to 2011. He is a former president and an honorary member of the Norwegian Concrete Society. He is a long-time member of ACI and a member of several ACI committees.

Per Jahren has written more than 150 papers, articles, and books on concrete, and has given lectures on concrete, and concrete and sustainability topics in particular, in 30 different countries.

Tongbo Sui, PhD, professor, is the founder and director general of Sinoma Research Institute and vice president of China Sinoma International Engineering Co. Ltd (Sinoma International) in Beijing. He joined Sinoma International in May 2010. Currently, as a visiting professor at Jinan University and Wuhan University of Technology, his focus is in the R&D of low energy and low CO₂ emission cements.

Before joining Sinoma International, he had been engaged in the R&D of special cements and new cementitious materials since 1991 in the China Building Materials Academy (CBMA), working as research engineer, senior engineer, chief of special cements division, and director of the Research Institute of Cement and New Building Materials under CBMA until February 2006. From March 2006 to April 2010, he was a professor and vice president of CBMA.

Dr. Sui has presided over 10 China state-supported key research projects in the cement and concrete area, as well as over 10 international cooperative projects with partners from Australia, France, Norway, and the United States. He is the recipient of various awards, including the national expert for excellent achievement in research on cement-based materials awarded by the State Council in 2005, and the second-class national prize for technological invention on low energy and low emission high belite cement awarded by the State Council in 2006. He also received an international award for his outstanding contribution to technology for cement and concrete sustainability at Seville, Spain in 2009 by the Organization of International Conferences for the Advances of Concrete Technology for Sustainable Development, formerly the CANMET/ACI Council.

He is the main founder of the International Center for Materials Technology Promotion under the United Nations Industrial Development Organization (UNIDO-ICM), located in Beijing since 2002. He had worked as director and international coordinator of UNIDO-ICM (2003–2007) for promoting technical diffusion and transfer in the building materials field and affordable housing technology for South-South cooperation. He is also the main organizer of many international symposiums and workshops in China in the cement and concrete sector.

He has been the co-chair of Task Force 1 for Climate Protection & Emission Reduction of Cement Sustainability Initiative, World Business Council for Sustainable Development (WBCSD-CSI) since 2011. Dr. Sui was a key member of the Cement Task Force–China under the seven-country Asian Pacific Partnership for Climate and Clean Mechanism (APP-CTF, 2006–2011). Additionally, he has held many memberships in professional associations, including deputy director of the Science and Education Committee of the China Building Materials Industry Federation, deputy director of the Cement Branch of the Chinese Ceramic Society, and member of ASTM C01, ACI and senior member of RILEM TC-SCM.

Dr. Sui was born in 1965 in Shandong, China, and graduated from the Department of Applied Chemistry in the Shandong Building Materials Institute with a BS degree in 1988, and from the Department of Inorganic Materials Science and Engineering in the China Building Materials Academy with an MS degree (1991) and a PhD degree (2001). He was a visiting researcher in 1996 in the Department of Civil Engineering and Environment at the University of Illinois, Urbana-Champaign, supported by the World Bank project.

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