

Architect's Guidebooks to Structures


CONCRETE DESIGN

Edited by Paul W. McMullin, Jonathan S. Price,
and Esra Hasanbas Persellin



Concrete Design

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Jonathan S. Price, and
Esra Hasanbas Persellin**

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Concrete Design

Concrete Design covers fundamentals for architects and engineers, such as tension, bending, shear, and compression elements, anchorage, lateral design, and footings. As part of the *Architect's Guidebooks to Structures* series, it provides a comprehensive overview using both imperial and metric units of measurement. Written by experienced professional structural engineers, *Concrete Design* is beautifully illustrated, with more than 170 black and white images, contains clear examples that show all design steps, and provides rules of thumb and simple tables for initial sizing. A refreshing change in textbooks for architectural materials courses, it is an indispensable reference for practicing architects and students alike. As a compact summary of key ideas, it is ideal for anyone needing a quick guide to concrete design.

Paul W. McMullin is an educator, structural engineer, and photographer. He holds degrees in mechanical and civil engineering and is a licensed engineer in numerous states. He is a founding partner of Ingenium Design, providing innovative solutions to industrial and manufacturing facilities. Currently an adjunct professor at the University of Utah in Salt Lake City, USA, he has taught for a decade and loves bringing project-based learning to the classroom.

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Esra Hasanbas Persellin is a structural engineer who has a great passion for engineering. She holds a Master of Science degree from the University of Utah, USA. She has published in the *ASCE Journal* and presented papers at conferences such as SME and SEAU. Her research specializes in vibration analysis and control. She works as a structural engineer at Millcreek Engineering.

Architect's Guidebooks to Structures

The *Architect's Guidebooks to Structures* series addresses key concepts in structures to help you understand and incorporate structural elements into your work. The series covers a wide range of principles, beginning with a detailed overview of structural systems, material selection, and processes in *Introduction to Structures*, following with topics such as *Concrete Design*, *Special Structures Topics*, *Masonry Design*, and *Timber Design*, and finishing with *Steel Design* to equip you with the basics to design key elements with these materials and present you with information on geotechnical considerations, retrofit, blast, cladding design, vibration, and sustainability.

Designed as quick reference materials, the *Architect's Guidebooks to Structures* titles will provide architecture students and professionals with the key knowledge necessary to understand and design structures. Each book includes imperial and metric units, rules of thumb, clear design examples, worked problems, discussions on the practical aspects of designs, and preliminary member selection tables; all in a handy, portable size.

Read more in the series blog: <http://architectsguidestructures.wordpress.com/>

Introduction to Structures

Paul W. McMullin and Jonathan S. Price

Concrete Design

Paul W. McMullin, Jonathan S. Price, and Esra Hasanbas Persellin

Special Structures Topics

Paul W. McMullin and Jonathan S. Price

Masonry Design

Paul W. McMullin and Jonathan S. Price

Timber Design

Paul W. McMullin and Jonathan S. Price

Steel Design

Paul W. McMullin, Jonathan S. Price, and Richard T. Seelos

For our parents

Phil and Joy

Frederick and Irene

Aysel and Orhan

holds a bachelor's degree and a master's degree in architecture from the University of Utah, USA. She is in the early stages of her architectural career, with an inclination towards design and details in project management. She comes from a fine art background with over 15 years' experience in hand drawing and rendering, and lends a 3-D approach to the understanding of structures.

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To our students who have suffered long and provided valuable insight on how to teach better.

We are unable to fully express our gratitude to each person involved in preparing this book. It is orders of magnitude better than it would have otherwise been thanks to their contributions.

Note on the Text

Glossary words are shown in **bold**. Consult the Glossary for definitions.

Metric versions of tables are shaded in blue.

There are also four Appendices for reference:

Appendix 1 List of Units

Appendix 2 List of Symbols

Appendix 3 Unit Conversion Tables

Appendix 4 Column Interaction Diagrams

Where appropriate, imperial calculations have been aligned to the left and the metric versions indented or aligned to the right.

Introduction

Paul W. McMullin,
Jonathan S. Price, and
Esra Hasanbas Persellin

Concrete is the fundamental building block of construction. From the Egyptians' use of lime to the Roman viaducts to today's skyscrapers, concrete has played a pivotal role in the development of civilization. We find it in the foundations of virtually all structures today and forms of entire structural systems. We use it in dams, water treatment facilities, bridges, industrial structures, schools, offices, and homes. It has infinite dimensional possibilities, is strong in compression, and durable.

We produce concrete from a wide range of **aggregates** and cements, making it remarkably flexible. The constituent parts and finished mix can be moved by hand or with large machinery. Placed in its fluid state, it has few limits on form. With the addition of reinforcing steel, it easily resists **tension** forces, launching it across large spans and presenting no code height limitations.

While concrete design can be complicated, once we understand the basics, the mystery disappears. However, this makes the understanding of key principles essential to its realization.

This guide is designed to give the student and budding architect a foundation to successfully understand and incorporate concrete in their designs. It builds on the first book in this series, *Introduction to Structures*, presenting the essence of what structural engineers use most for concrete design.

If you are looking for the latest concrete trends, or to plumb the depths of technology, you're in the wrong place. If you want a book devoid of equations and legitimate engineering principles, return this book

immediately and invest your money elsewhere. However, if you want a book that holds architects and engineers as intellectual equals, opening the door of concrete design to you, you are very much in the right place.

Yes, this book has equations. They are the language of engineering. They provide a picture of how structure changes when a variable is modified. To disregard equations is like dancing with our feet tied together.

This book is full of in-depth design examples, written the way practicing engineers design. These can be built upon by reworking examples in class with different variables. Better yet, assign small groups of students to rework the example, each with new variables. Afterward, have them present their results and discuss the trends and differences.

For learning assessment, consider assigning a design project. Students can use a past studio project, or a building that interests them. The project can start with determining structural loads, continue with designing key members, and end with consideration of connection and seismic design. They can submit design calculations and sketches summarizing their work and present their designs to the class. This approach requires a basic level of performance, while allowing students to dig deeper into areas of interest. Most importantly, it places calculations in context; providing an opportunity to wrestle with the iterative nature of design, and experience the discomfort of learning a new language.

Our great aim is to bridge the gap between structural engineering and architecture. A gap that historically didn't exist, and is unnecessarily wide today. This book is authored by practicing engineers, who understand the technical nuances and the big picture of how a concrete project goes together. We hope it opens the door for you.

The National Assembly Building, Dhaka, Bangladesh (Sher-e-Bangla Nagar Capital)

Chapter 1

Jonathan S. Price

Contents

List of Figures	xiii
List of Tables	xx
Notes on Contributors	xxii
Acknowledgments	xxiv
Note on the Text	xxv
 Introduction	 xxvi
<i>Paul W. McMullin, Jonathan S. Price, and Esra Hasanbas Persellin</i>	
 1 The National Assembly Building, Dhaka, Bangladesh (Sher-e-Bangla Nagar Capital)	 1
<i>Jonathan S. Price</i>	
1.1 Introduction	1
1.2 Design	2
1.3 Architectural Concrete	6
1.4 Construction	14
 2 Concrete Fundamentals	 18
<i>Paul W. McMullin</i>	
2.1 Historical Overview	19
2.2 Codes	19
2.3 Materials	24
2.4 Material Behavior	46
2.5 Structural Configuration	55
2.6 Section Properties	57
2.7 Construction	57
2.8 Quality Control	61
2.9 Where We Go from Here	66

3 Concrete Tension	68
<i>Esra Hasanbas Persellin</i>	
3.1 Stability	70
3.2 Capacity	70
3.3 Demand vs. Capacity	70
3.4 Deflection	72
3.5 Detailing	72
3.6 Where We Go from Here	77
4 Concrete Bending	78
<i>Paul W. McMullin</i>	
4.1 Stability	80
4.2 Capacity	80
4.3 Demand vs. Capacity	91
4.4 Deflection	92
4.5 Detailing Considerations	93
4.6 Where We Go from Here	109
5 Concrete Shear	110
<i>Esra Hasanbas Persellin</i>	
5.1 Introduction	111
5.2 Stability	114
5.3 Shear Strength	114
5.4 Demand vs. Capacity	120
5.5 Deflection	121
5.6 Detailing Considerations	121
5.7 Where We Go from Here	133
6 Concrete Compression	134
<i>Paul W. McMullin</i>	
6.1 Stability	136
6.2 Capacity: Interaction Diagrams	139