# Contents

## Preface

## Chapter 1

**Introduction and Overview**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Shifting Landscape for Green Buildings</td>
<td>1</td>
</tr>
<tr>
<td>The Roots of Sustainable Construction</td>
<td>5</td>
</tr>
<tr>
<td>Sustainable Development and Sustainable Construction</td>
<td>8</td>
</tr>
<tr>
<td>The Vocabulary of Sustainable Development and Sustainable Construction</td>
<td>9</td>
</tr>
<tr>
<td>Sustainable Design, Ecological Design, and Green Design</td>
<td>12</td>
</tr>
<tr>
<td>Rationale for High-Performance Green Buildings</td>
<td>14</td>
</tr>
<tr>
<td>State and Local Guidelines for High-Performance Construction</td>
<td>14</td>
</tr>
<tr>
<td>Green Building Progress and Obstacles</td>
<td>16</td>
</tr>
<tr>
<td>Trends in High-Performance Green Building</td>
<td>18</td>
</tr>
<tr>
<td>Book Organization</td>
<td>24</td>
</tr>
<tr>
<td>Case Study: The Pertamina Energy Tower: A Primer on Green Skyscraper Design</td>
<td>25</td>
</tr>
<tr>
<td>Summary and Conclusions</td>
<td>34</td>
</tr>
<tr>
<td>Notes</td>
<td>34</td>
</tr>
<tr>
<td>References</td>
<td>35</td>
</tr>
</tbody>
</table>

## Part I

**Green Building Foundations**

## Chapter 2

**Background**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Driving Forces for Sustainable Construction</td>
<td>44</td>
</tr>
<tr>
<td>Ethics and Sustainability</td>
<td>46</td>
</tr>
<tr>
<td>Basic Concepts and Vocabulary</td>
<td>55</td>
</tr>
<tr>
<td>Major Environmental and Resource Concerns</td>
<td>65</td>
</tr>
<tr>
<td>The Green Building Movement</td>
<td>70</td>
</tr>
<tr>
<td>Case Study: OWP 11, Stuttgart, Germany</td>
<td>78</td>
</tr>
<tr>
<td>Summary and Conclusions</td>
<td>81</td>
</tr>
<tr>
<td>Notes</td>
<td>82</td>
</tr>
<tr>
<td>References</td>
<td>83</td>
</tr>
</tbody>
</table>
Chapter 3

Ecological Design  87

Design versus Ecological Design  88
Contemporary Ecological Design  96
Key Green Building Publications: Early 1990s  97
Key Thinking about Ecological Design  99
Evolving the Concept of Ecological Design  104
Thermodynamics: Limits on Recycling and the Dissipation of Materials  114
Case Study: Kroon Hall, Yale University, New Haven, Connecticut  118
Thought Piece: Regenerative Development and Design: Working with the Whole by Bill Reed  121
Summary and Conclusions  123
Notes  123
References  123

Part II

Assessing High-Performance Green Buildings  127

Chapter 4

Green Building Assessment  129

Purpose of Green Building Assessment Systems  129
Major Green Building Assessment Systems Used in the United States  133
International Building Assessment Systems  136
BREEAM Case Study: AHVLA Stores Building, Weybridge, United Kingdom  138
Green Star Case Study  144
Thought Piece: Shifting Emphasis in Green Building Performance Assessment by Raymond J. Cole  149
Summary and Conclusions  151
Notes  152
References  152

Chapter 5

The US Green Building Council LEED Building Rating System  155

Brief History of LEED  156
Structure of the LEED Suite of Building Rating Systems  158
LEED Credentials  160
LEED v4 Structure and Process  161
LEED Building Design and Construction Rating System  166
Case Study: University of Florida Research and Academic Center at Lake Nona in Orlando, Florida  183  
Summary and Conclusions  187

## Chapter 6

**The Green Globes Building Assessment System**  189

- Green Globes Building Rating Tools  190
- Structure of Green Globes for New Construction  192
- Green Globes Assessment and Certification Process  204
- Green Globes Professional Credentials  206
- Case Study: Health Sciences Building, St. Johns River State College, St. Augustine, Florida  207
- Summary and Conclusions  211

## Part III

**Green Building Design**  213

## Chapter 7

**The Green Building Design Process**  215

- Conventional versus Green Building Delivery Systems  215
- Executing the Green Building Project  219
- Integrated Design Process  223
- Role of the Charrette in the Design Process  228
- Green Building Documentation Requirements  230
- Case Study: Theaterhaus, Stuttgart, Germany  231
- Summary and Conclusions  235
- Notes  236

## Chapter 8

**The Sustainable Site and Landscape**  237

- Land and Landscape Approaches for Green Buildings  238
- Land Use Issues  239
- Sustainable Landscapes  245
- Enhancing Ecosystems  252
- Stormwater Management  253
- Low-Impact Development  254
- Heat Island Mitigation  258
- Light Trespass and Pollution Reduction  259
- Assessment of Sustainable Sites: The Sustainable Sites Initiative  260
Chapter 9

Low-Energy Building Strategies

Building Energy Issues 270
High-Performance Building Energy Design Strategy 274
Passive Design Strategy 277
Building Envelope 285
Internal Load Reduction 291
Active Mechanical Systems 293
Water-Heating Systems 298
Electrical Power Systems 299
Innovative Energy Optimization Strategies 305
Renewable Energy Systems 308
Fuel Cells 311
Smart Buildings and Energy Management Systems 312
Ozone-Depleting Chemicals in HVAC&R Systems 313
Case Study: River Campus Building One, Oregon Health and Science University, Portland 314
Thought Piece: Building Energy Analysis: The Present and Future by Ravi Srinivasan 319
Summary and Conclusions 321
Notes 321
References 322

Chapter 10

Built Environment Hydrologic Cycle

Global Water Resource Depletion 326
Water Distribution and Shortages in the United States 327
Hydrologic Cycle Terminology 331
High-Performance Building Hydrologic Cycle Strategy 333
Designing the High-Performance Building Hydrologic Cycle 349
Water Budget Rules of Thumb (Heuristics) 353
Sustainable Stormwater Management 353
Landscaping Water Efficiency 361
Case Study: LOTT Clean Water Alliance, Olympia, Washington 362
Summary and Conclusions 365
Notes 365
References 366
## Chapter 11

### Closing Materials Loops 367

- **The Challenge of Materials and Product Selection** 368
- **Distinguishing between Green Building Products and Green Building Materials** 370
- **LCA of Building Materials and Products** 378
- **Environmental Product Declarations** 381
- **Materials and Product Certification Systems** 383
- **Key and Emerging Construction Materials and Products** 385
- **Design for Deconstruction and Disassembly** 390
- **Case Study: Project XX Office Building, Delft, Netherlands** 393
- **Thought Piece: Closing Materials Loops by Bradley Guy** 396
- **Summary and Conclusions** 397
- **Notes** 398
- **References** 398

## Chapter 12

### Built Environment Carbon Footprint 401

- **Human Impacts on the Biogeochemical Carbon Cycle** 402
- **Climate Change and the Carbon Cycle** 404
- **Mitigating Climate Change** 408
- **Defining the Carbon Footprint of the Built Environment** 411
- **Reducing the Carbon Footprint of the Built Environment** 418
- **Notes** 419
- **References** 419

## Chapter 13

### Indoor Environmental Quality 421

- **Indoor Environmental Quality: The Issues** 421
- **Integrated IEQ Design** 430
- **Addressing the Main Components of Integrated IEQ Design** 433
- **HVAC System Design** 450
- **Emissions from Building Materials** 452
- **Particleboard and Plywood** 456
- **Economic Benefits of Good IEQ** 459
- **Health, Well-Being, and Productivity** 460
- **Summary and Conclusions** 463
- **Notes** 463
- **References** 464
Part IV

Green Building Implementation 465

Chapter 14

Construction Operations and Commissioning 467

Site Protection Planning 467
Managing Indoor Air Quality during Construction 471
Construction Materials Management 475
Construction and Demolition Waste Management 478
Commissioning 480
Thought Piece: The Role of Commissioning in High-Performance Green Buildings by John Chyz 486
Summary and Conclusions 488
Notes 489
References 489

Chapter 15

Green Building Economics 491

General Approach 491
The Business Case for High-Performance Green Buildings 494
Economics of Green Building 496
Quantifying Green Building Benefits 498
Managing First Costs 505
Tunneling through the Cost Barrier 508
Summary and Conclusions 510
Notes 510
References 510

Chapter 16

The Cutting Edge of Sustainable Construction 513

Resilience 514
Cutting Edge: Case Studies 516
Case Study: The Federal Building, San Francisco, California 516
Articulating Performance Goals for Future Green Buildings 520
The Challenges 521
Revamping Ecological Design 528
Today’s Cutting Edge 531
Case Study: Green Skyscrapers 534
Thought Piece: Processes, Geometries, and Principles: Design in a Sustainable Future by Kim Sorvig 543
### Appendix A

**Quick Reference for LEED 3.0** 547

### Appendix B

**The Sustainable Sites Initiative™ (SITES™) v2 Rating System for Sustainable Land Design and Development** 551

### Appendix C

**Unit Conversions** 555

### Appendix D

**Abbreviations and Acronyms** 557

### Appendix E

**WELL Building Standard® Features Matrix** 563

**Glossary** 567

**Index** 579