## Figure Credits

ix

## Acknowledgments

xi

## Introduction

xiii

### CHAPTER 1

**CLIMATE-BASED DESIGN APPROACH FOR FACADES**

1

- **Climate Classifications and Types**
  3

- **Climate-Specific Design Guidelines for Facades**
  8
  - Environmental Considerations and Design Criteria
  8
  - Design Strategies and Climate
  9

**Chapter Summary**

14

### CHAPTER 2

**CHARACTERISTICS OF SUSTAINABLE FACADES**

17

- **Energy Efficiency**
  18
  - Orientation
  19
  - Fenestration
  24

- **Facade Types and Materials**
  40
  - Opaque Building Facades
  40
  - Glazed Building Facades
  48

- **Materials and Properties**
  54
  - Properties of Facade Materials and Components
  54
  - Embodied Energy of Materials
  62

- **Thermal Behavior and Moisture Resistance**
  66
  - Control of Heat Transfer, and Air and Moisture Movement
  66
  - Steady-State Heat and Moisture Transfer Analysis for Opaque Building Facades
  69
  - Hygrothermal Analysis for Opaque Building Facades
  74
  - Heat Transfer Analysis for Glazed Building Facades
  79

**Chapter Summary**

83
## CHAPTER 3  DESIGNING FOR COMFORT  85

**Thermal Comfort**  86
- Methods of Measurement  87
- Facade Design and Thermal Comfort  91

**Daylight and Glare**  95
- Daylighting Strategies  95
- Glare  109

**Acoustic Comfort and Air Quality**  115
- Acoustics  115
- Air Quality  118

**Chapter Summary**  119

## CHAPTER 4  EMERGING TECHNOLOGIES IN FACADE DESIGNS  121

**Emerging Materials and Technologies**  122
- Advanced Facade Materials  122
- Smart Materials  126

**Double-Skin Facades**  135
- Double-Skin Facades in Hot and Arid Climates  141
- Double-Skin Facades in Cold Climates  143

**Facades as Energy Generators**  149

**Control Systems for Facades**  153

**Chapter Summary**  155

## CHAPTER 5  CASE STUDIES  157

**Building Orientation and Facade Design**  159
- Arizona State University Interdisciplinary Science & Technology Building  159
- Center for Urban Waters  167

**Tectonic Sun Exposure Control**  178
- Kuwait University College of Education  178
- King Abdullah Financial District Parcel 4.01 Building  186
- King Abdullah Financial District Parcel 4.10 Building  200

**External Shading Elements**  211
- University of Texas Dallas Student Services Building  211

**Facade Materials and Wall Assemblies**  218
- Bigelow Laboratory for Ocean Sciences  218
APPENDIX

CASE STUDIES INDEX

Chapter 2
Case Study 2.1: Vincent Triggs Elementary School, Clark County Elementary Prototype (Las Vegas, Nevada) 228
Case Study 2.2: Hector Garcia Middle School (Dallas, Texas) 228
Case Study 2.3: Kendal Academic Support Center, Miami Dade College (Miami, Florida) 229

Chapter 3
Case Study 3.1: Centers for Disease Control and Prevention, National Center for Environmental Health (Atlanta, Georgia) 229

Chapter 4
Case Study 4.1: Princess Nora Bint Abdulrahman University for Women Academic Colleges (Riyadh, Saudi Arabia) 230
Case Study 4.2: Tinkham Veale University Center, Case Western Reserve University (Cleveland, Ohio) 230

Chapter 5
Interdisciplinary Science & Technology Building, Arizona State University (Tempe, Arizona) 231
Center for Urban Waters (Tacoma, Washington) 232
Kuwait University College of Education (Shadadiyah, Kuwait) 232
King Abdullah Financial District Parcel 4.01 Building (Riyadh, Saudi Arabia) 233
King Abdullah Financial District Parcel 4.10 Building (Riyadh, Saudi Arabia) 233
University of Texas Dallas Student Services Building (Dallas, Texas) 234
Bigelow Laboratory for Ocean Sciences (East Boothbay, Maine) 234

Index 235