# INTEGRATING INNOVATION IN ARCHITECTURE

Design, Methods and Technology for Progressive Practice and Research



## CONTENTS

#### ACKNOWLEDGEMENTS 7

FOREWORD 9-11 by Phil Harrison

#### INTRODUCTION

#### INNOVATION IN ARCHITECTURE (WHAT. WHY AND HOW) 12-19

What is innovation? 13 Why innovate in architectural design? 16 How to innovate in architecture? 17

#### **1 INNOVATIVE MATERIALS 20-59**

Advances in concrete 23 Advances in glass 27 Advances in metals 37 Biomaterials 39 Composite materials 41 Electrochromics 45 Shape-memory alloys 45 Self-healing materials 47 Sensors and controls 48 Phase-change materials 49 Photovoltaics 51 Thermoelectrics 55 Conclusion: the impacts of advanced and smart materials on architectural design 57

#### 2 INNOVATIONS IN COMPUTATIONAL DESIGN 60-127

Advances in computational design 63 Tools and methods 77 BIM in design 88 BIM in virtual construction 91 BIM in facility management 95 Environmental simulations and energy analysis 98 Structural analysis 101 CFD analysis 105 Digital fabrication and methods 111 Design to fabrication 121 Conclusion: the integration of advanced computational technologies with design and research 125

#### **3 TECHNOLOGICAL INNOVATIONS 128-169**

Advances in facade systems 131 Advances in HVAC systems 135 Advances in lighting 145 Building automation systems 151 Prefabrication and modular construction 156 Automation in construction 159 Robotics in construction 162 Smart and responsive buildings 163 Conclusion: the integration of advanced technologies in design and construction 167

#### 4 INNOVATIONS IN THE DESIGN PROCESS AND ARCHITECTURAL PRACTICE 170-183

Motives and goals for innovation 171 Organisation and roles 172 Integration of research and design practice 174 Research methods for innovation 176 Financial factors and investments for innovation 177 Value of innovation 179 Innovations in project delivery 179 Risk management in innovative design practice 181 Conclusion: strategies for integrating innovation 183

### 5 BUILDING INTEGRATED INNOVATIONS AND METHODS (CASE STUDIES) 184-245

Center for Design Research, University of Kansas 187 Umwelt Arena 191 King Fahad National Library 199 Hanjie Wanda Square 205 Collaborative Life Sciences Building and Skourtes Tower 211 Shanghai Natural History Museum 219 The Yas Hotel 229 Health Sciences Education Building, Phoenix Biomedical Campus 233 Conclusion: lessons learned from case studies 243

#### FUTURE OUTLOOKS: CONCLUDING REMARKS 246-249

#### SELECT BIBLIOGRAPHY 250-253

#### APPENDIX: CASE STUDIES INDEX 254-259

INDEX 260-264