

Chapter 1

Introduction

Big Idea

“Entrusted by society to create a sustainable world and enhance the global quality of life, Civil Engineers serve, competently, collaboratively, and ethically as: master planners, designers, constructors; stewards of the natural environment and its resources; innovators and integrators; managers of risk and uncertainty; and leaders in discussions and decisions shaping public environmental and infrastructure policy.”

—ASCE Body of Knowledge 2

Key Topics Covered

- The Need for Accreditation
- American Society of Civil Engineers (ASCE)
- 21st Century Engineer
- Goal of This Book
- Reader's Guide

Related Chapters in This Book

- Chapters 2 through 17 and Appendices A, B, C, D, E, F

(Continued)

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Related to ASCE Body of Knowledge 2 Outcomes

ASCE BOK2 outcomes covered in this chapter				
Foundational	1. Mathematics	5. Materials science	Professional	● 16. Communication
	2. Natural sciences	6. Mechanics		● 17. Public policy
	3. Humanities	7. Experiments		● 18. Business and public administration
	4. Social sciences	● 8. Problem recognition and solving		● 19. Globalization
Technical	● 9. Design	● 9. Design	● 20. Leadership	
	● 10. Sustainability	● 10. Sustainability	● 21. Teamwork	
	● 11. Contemporary issues & historical perspectives	● 11. Contemporary issues & historical perspectives	● 22. Attitudes	
	● 12. Risk and uncertainty	● 12. Risk and uncertainty	● 23. Lifelong learning	
	● 13. Project management	● 13. Project management	● 24. Professional and ethical responsibility	
	● 14. Breadth in civil engineering areas	● 14. Breadth in civil engineering areas		
	● 15. Technical specialization	● 15. Technical specialization		

BACKGROUND

The *Civil Engineer's Handbook of Professional Practice* is a professional practice guide for civil engineers. The first decade of the 21st century has afforded many opportunities to reflect on the role civil engineers will play in coming years. The global economy and world banking system, national security, climate change, dwindling natural resources, technological advances, and societal changes have provided sufficient food for thought. In retrospect, the 2001 American Society of Civil Engineers (ASCE) report, titled *Engineering the Future of Civil Engineering*, which acknowledged that civil engineering must respond proactively to increasingly complex challenges related to public health, safety, and welfare, appears prophetic.

As a university program, civil engineering has been growing in the 21st century. Enrollment in most universities across the nation continues to increase, partially due to shrinking opportunities in other technical fields as a result of outsourcing. Civil engineers work very closely with government agencies and on projects requiring significant local knowledge, making outsourcing of their work difficult. According to the U.S. Bureau of Labor Statistics:

Civil engineers are expected to experience 24 percent employment growth during the projections decade [2008–2018], faster than the average for all occupations. Spurred by general population growth and the related need to improve the Nation's infrastructure, more civil engineers will be needed to design and construct or expand transportation, water supply, and pollution control systems and buildings and building complexes. They also will be needed to repair or replace existing roads, bridges, and other public structures.

For several years the country's infrastructure has been given a grade of "D" on the ASCE's infrastructure report card; in 2009 the ASCE estimated that a \$2.2 trillion investment was needed over the next five years to rectify this problem. Significant public and private funding sources have been established to address this challenge and, as a result, the demand for well-educated and competent civil engineers should continue.

"Infrastructure is a multitrillion-dollar marketplace with enormous need for private investment."

Source: Henry Kravis in the New York Times, 5/16/08

THE NEED FOR ACCREDITATION

ASCE has made a concerted effort to work with ABET, Inc., formerly named the Accreditation Board for Engineering and Technology, to assure that civil engineering education anticipates and responds to the profession's evolving needs. ASCE has formed several task forces not only to address these needs in the present but also to foresee significant trends.

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ABET, Inc. accredits civil engineering programs within U.S. universities and plays a significant role in determining the development of the profession. University Departments of Civil Engineering undergo extensive, periodic reviews by ABET in order to maintain their accreditation.

ABET, Inc. was established more than 75 years ago as the Engineers' Council for Professional Development (ECPD). A survey of multiple engineering societies revealed the need for quality control, and in 1932, seven societies founded ECPD. These societies included: the American Society of Civil Engineers (ASCE); the American Society of Mining and Metallurgical Engineers (now the American Institute of Mining, Metallurgical, and Petroleum Engineers); the American Society of Mechanical Engineers (ASME); the American Institute of Electrical Engineers (now IEEE); the Society for Promotion of Engineering Education (now the American Society for Engineering Education—ASEE); the American Institute of Chemical Engineers (AIChE); and the National Council of State Boards of Engineering Examiners (now NCEES). By 2009, ABET accredited approximately 2,700 programs at more than 550 universities and colleges nationwide.

ABET OUTCOMES

Following a long period of development, in 1997, ABET adopted Engineering Criteria 2000 (EC2000), which took a completely new approach to engineering education. By defining *outcomes* of engineering education, EC2000 focused on what is learned rather than what is taught. ABET has identified 11 outcomes of civil engineering education:

1. *Mathematics, science, and engineering*—an ability to apply knowledge of mathematics, science, and engineering
2. *Experiments*—an ability to design and conduct experiments, as well as analyze and interpret data
3. *Design*—an ability to design a system, component, or process to meet desired needs
4. *Multidisciplinary teams*—an ability to function on multidisciplinary teams
5. *Engineering problems*—an ability to identify, formulate, and solve engineering problems
6. *Professional and ethical responsibility*—an understanding of professional and ethical responsibility
7. *Communication*—an ability to communicate effectively
8. *Impact of engineering*—the broad education necessary to understand the impact of engineering solutions in a global and societal context
9. *Lifelong learning*—a recognition of the need for, and an ability to engage in, lifelong learning

10. *Contemporary issues*—a knowledge of contemporary issues
11. *Engineering tools*—an ability to understand techniques, skills, and modern engineering tools necessary for engineering practice

AMERICAN SOCIETY OF CIVIL ENGINEERS

Meanwhile, the American Society of Civil Engineers has made a concerted effort to work with ABET to assure that civil engineering education anticipates and responds to the profession's evolving needs.

The ASCE has formed several task forces not only to address these needs in the present but also to foresee significant trends. Policy 465 expresses the vision articulated by the Summit on the Future of Civil Engineering–2025 held in 2006. The attendees of the Summit saw civil engineers as being entrusted by society to be leaders in creating a sustainable world and enhancing the global quality of life. As depicted in Figure 1.1, Policy 465 supports the concept of the master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at the professional level.

The 2001 ASCE report *Engineering the Future of Civil Engineering*, mentioned above, concluded that for civil engineers to maintain leadership in the infrastructure and environmental arena, an implementation master plan was needed; and the basis of this master plan is a document called the *Body of Knowledge*. The *Body of Knowledge 1*

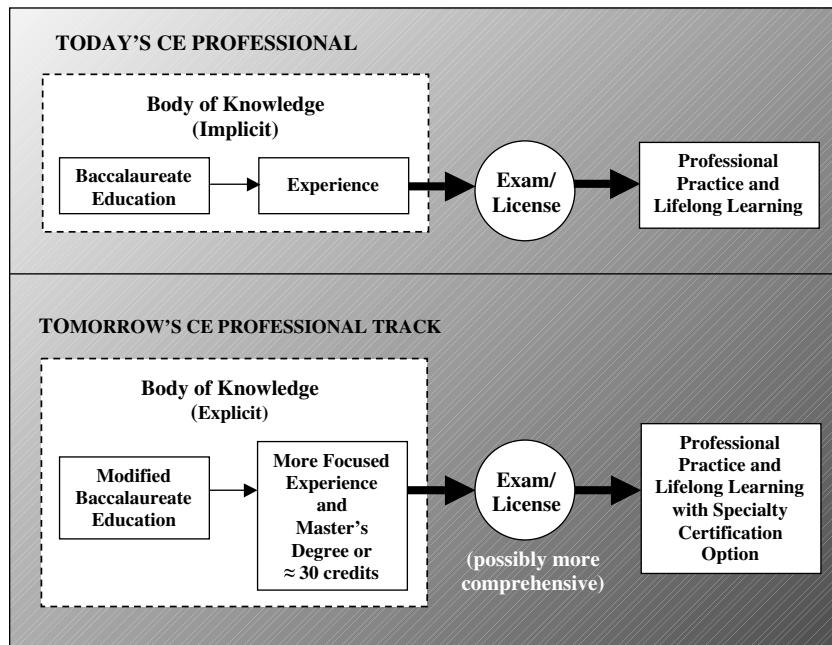


Figure 1.1 ASCE's vision of preparation for a career in civil engineering
(Adapted from ASCE Policy Statement 465)

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(BOK1), published in 2004, defines categories of knowledge and recommends 15 outcomes that collectively prescribe a “substantially greater depth and breadth of knowledge, skills, and attitudes required of an individual aspiring to the practice of civil engineering at the professional level (licensure) in the 21st Century.” The first 11 outcomes are those identified by ABET, but the BOK1 included four additional outcomes that broaden and deepen these ABET outcomes. The new outcomes are:

12. *Specialization*—an ability to apply knowledge in a specialized area related to civil engineering
13. *Management*—an understanding of the elements of project management, construction, and asset management
14. *Policy and administration*—an understanding of business and public policy and administration fundamentals
15. *Leadership*—an understanding of the role of the leader and leadership principles and attitudes

The BOK1 also emphasized the importance of attitude: “knowledge and skill, while necessary, are not sufficient to be a fully functioning civil engineer.” (Note: ABET has incorporated outcomes 13, 14, and 15 into its Criterion 9 for civil engineering programs.)

ASCE published the second edition of BOK1, the *Body of Knowledge 2* (BOK2), in 2008. The BOK2 also uses the “outcomes” approach developed by ABET to define the knowledge, skills, and attitudes necessary to enter civil engineering practice at the professional level in the 21st century. The BOK2 further adopts Bloom’s Taxonomy to indicate the desired level of achievement for each outcome. The BOK2’s 24 outcomes are organized into three categories: foundational, technical, and professional. (See Table 1.1.)

Table 1.1 BOK2 Outcomes (2008)

Foundational	Technical	Professional
1) mathematics	5) materials science	16) communication
2) natural sciences	6) mechanics	17) public policy
3) humanities	7) experiments	18) business and public administration
4) social sciences	8) problem recognition and solving	19) globalization
	9) design	20) leadership
	10) sustainability	21) teamwork
	11) contemporary issues/historical perspectives	22) attitudes
	12) risk and uncertainties	23) lifelong learning
	13) project management	24) professional and ethical responsibility
	14) breadth in civil engineering areas	
	15) technical specialization	

ASCE Has Developed a Global Vision of the Profession:

Entrusted by society to create a sustainable world and enhance the global quality of life, Civil Engineers serve, competently, collaboratively, and ethically as master:

- Planners, designers, constructors, and operators of society's economic and social engine, the built environment
- Stewards of the natural environment and its resources
- Innovators and integrators of ideas and technology across the public, private, and academic sectors
- Managers of risk and uncertainty caused by natural events, accidents, and other threats
- Leaders in discussions and decisions shaping public environmental and infrastructure policy

—*Civil Engineering Body of Knowledge for the 21st Century (BOK2)*.

The first and second editions of the *Civil Engineering Body of Knowledge for the 21st Century* stress the need for change in the way civil engineers practice their profession and in the way they are educated. Though not strictly prescriptive, BOK1 and BOK2 offer guidance to academia in helping to educate future engineers. Summary findings are highlighted below.

Key issues facing engineering education

BOK1 identifies the chief issues facing civil engineering as:

- Escalated complex risks and challenges to public safety, health, and welfare
- Vulnerability to human-made hazards and disasters (such as terrorism)
- Globalization
- Four-year bachelor's degree inadequacy in providing formal academic preparation for the practice of civil engineering at the professional level

BOK2 adds further concerns:

- Sustainability
- Emerging technology

Teaching/learning modes

BOK1 identifies four teaching/learning modes:

- Undergraduate study typically leading to a BSCE
- Graduate study or equivalent

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- Co-curricular and extracurricular activities
- Post-B.S. engineering experience prior to licensure

BOK1 also concludes that distance learning increasingly will improve accessibility to high-quality formal education.

Faculty member characteristics

BOK1 identifies characteristics of the model full- or part-time civil engineering faculty member:

- *Scholars* having and maintaining expertise in the subjects they teach
- *Teachers* who effectively engage students in the learning process
- *Professionals* with practical experience, preferably with professional engineering licenses
- *Positive role models* for the profession

Table 1.2 depicts the relationships among the ABET, BOK1, and BOK2 outcomes.

What Is the Role of Engineers in Society and How Is that Role Changing?

- By 2020, we aspire to a public that will understand and appreciate the profound impact of the influence of the engineering profession on sociocultural systems, the full spectrum of career opportunities accessible through an engineering education, and the value of an engineering education to engineers working successfully in non-engineering jobs.
- We aspire to a public that will recognize the union of professionalism, technical knowledge, social and historical awareness, and traditions that serve to make engineers competent to address the world's complex and changing challenges.
- We aspire to engineers who will remain well grounded in the basics of mathematics and science, and who will expand their vision of design through solid grounding in the humanities, social sciences, and economics. Emphasis on the creative process will allow more effective leadership in the development and application of the next-generation technologies to problems of the future.

—National Academy of Engineering, *The Engineer of 2020*.

Table 1.2 From ABET to BOK2 Outcomes
(Adapted from Table H-1. From ABET program criteria to BOK2 outcomes. *Civil Engineering Body of Knowledge for the 21st Century, February 2008, p. 101.*)

ABET Outcomes	BOK1 Outcomes (2004)	BOK2 Outcomes (2008)
a. Mathematics, science, and engineering	1) Mathematics, science, and engineering	1) Mathematics 2) Natural Sciences 5) Materials Science 6) Mechanics
b. Experiments	2) Experiments	7) Experiments
c. Design	3) Design	9) Design 10) Sustainability
	3) Design	12) Risk and uncertainties
d. Multidisciplinary teams	4) Multidisciplinary teams	21) Teamwork
e. Engineering problems	5) Engineering problems	8) Problem recognition and solving
f. Professional and ethical responsibility	6) Professional and ethical responsibility	24) Professional and ethical responsibility
g. Communication	7) Communication	16) Communication
h. Impact of engineering	8) Impact of engineering	11) Contemporary issues/historical perspectives
i. Lifelong learning	9) Lifelong learning	23) Lifelong learning
j. Contemporary issues	10) Contemporary issues	11) Contemporary issues/historical perspectives 19) Globalization
k. Engineering tools	12) Engineering tools	8) Problem recognition and solving
	13) Specialized area related to civil engineering	15) Technical specialization
Program Criteria for Civil and Similarly Named Engineering Programs	14) Project management, construction, and asset management	13) Project management
	15) Business and public policy	17) Public policy 18) Business and public administration
Program Criteria for Civil and Similarly Named Engineering Programs	16) Leadership	20) Leadership 22) Attitudes
ABET Criterion for General Education	ABET Criterion for General Education	3) Humanities 4) Social sciences
Program Criteria for Civil and Similarly Named Engineering Programs	Program Criteria for Civil and Similarly Named Engineering Programs	14) Breadth in civil engineering areas

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Table 1.3 Entry into the Practice of Civil Engineering at the Professional Level Requires Fulfilling 24 Outcomes to the Appropriate Levels of Achievement

Outcome Number and Title	Level of Achievement					
	1 Knowledge	2 Compre- hension	3 Application	4 Analysis	5 Synthesis	6 Evaluation
<i>Foundational</i>						
1. Mathematics	B	B	B			
2. Natural sciences	B	B	B			
3. Humanities	B	B	B			
4. Social sciences	B	B	B			
<i>Technical</i>						
5. Materials science	B	B	B			
6. Mechanics	B	B	B	B		
7. Experiments	B	B	B	B	M/30	
8. Problem recognition and solving	B	B	B	M/30		
9. Design	B	B	B	B	B	E
10. Sustainability	B	B	B	E		
11. Contemp. issues & hisL perspectives	B	B	B	E		
12. Risk and uncertainty	B	B	B	E		
13. Project management	B	B	B	E		
14. Breadth in civil engineering areas	B	B	B	B		
15. Technical specialization	B	M/30	M/30	M/30	M/30	E
<i>Professional</i>						
16. Communication	B	B	B	B	E	
17. Public policy	B	B	E			
18. Business and public administration	B	B	E			
19. Globalization	B	B	B	E		
20. Leadership	B	B	B	E		
21. Teamwork	B	B	B	E		
22. Attitudes	B	B	E			
23. Lifelong learning	B	B	B	E	E	
24. Professional and ethical responsibility	B	B	B	B	E	E

Key:

B	Portion of the BOK fulfilled through the bachelor's degree
M/30	Portion of the BOK fulfilled through the master's degree or equivalent (approximately 30 semester credits of acceptable graduate-level or upper-level undergraduate courses in a specialized technical area and/or professional practice area related to civil engineering)
E	Portion of the BOK fulfilled through the prelicensure experience

The BOK2 not only defined outcomes but also identified what level of proficiency should be achieved for each outcome through the use of Blooms' taxonomy. Table 1.3 depicts the BOK2's 24 outcomes with the level of proficiency expected for each outcome.

21ST CENTURY ENGINEER

Aspiring civil engineers face challenges posed by the unique attributes and characteristics of facilities and civil infrastructure systems, as well as the complexities of the current processes and the diverse set of resources required for both their delivery and their use.

BOK2 gives some structure to what is a large educational challenge. These new outcomes and approaches have raised the bar substantially for civil engineering educators. Twentieth-century civil engineering education focused on learning about engineering mechanics; doing calculations; writing essays and lab reports; acquiring knowledge; and working with determinant processes. Twenty-first-century civil engineering practice requires innovative thinking and relies heavily on tacit knowledge—understanding, judgment, associativity, and intuition. (MacLeod, 2009) (See Figure 1.2.)

GOAL OF THIS BOOK

Given these complexities, the question is: How can the new BOK outcomes be achieved? Clearly, each of the BOK2's 24 outcomes could command its own textbook. The goal of this book is to provide an easily understood and readily usable resource for civil engineering educators, students, and professional practitioners that develops overall understanding and points readers to additional resources for further study. The book distills 15 of the BOK2's outcomes (six technical outcomes and all nine professional outcomes) as well as other relevant issues.

The *Civil Engineer's Handbook of Professional Practice* targets both academia and industry. The book can be used as a textbook for Professional Practice, Senior Project, Infrastructure Engineering, and Engineering Project Management courses. It is intended for junior, senior, and graduate level students in the major. As the issues addressed in the 2008 BOK2 are disseminated and better understood by educators, all Civil Engineering Departments will need to offer a course on Practice Management, if they do not do so already.

Additionally, the book is a helpful reference for practicing civil engineers. The information imbedded in the 191-page BOK2 provides a vision for a civil engineering body of knowledge. The *Civil Engineer's Handbook of Professional Practice* builds on that vision.

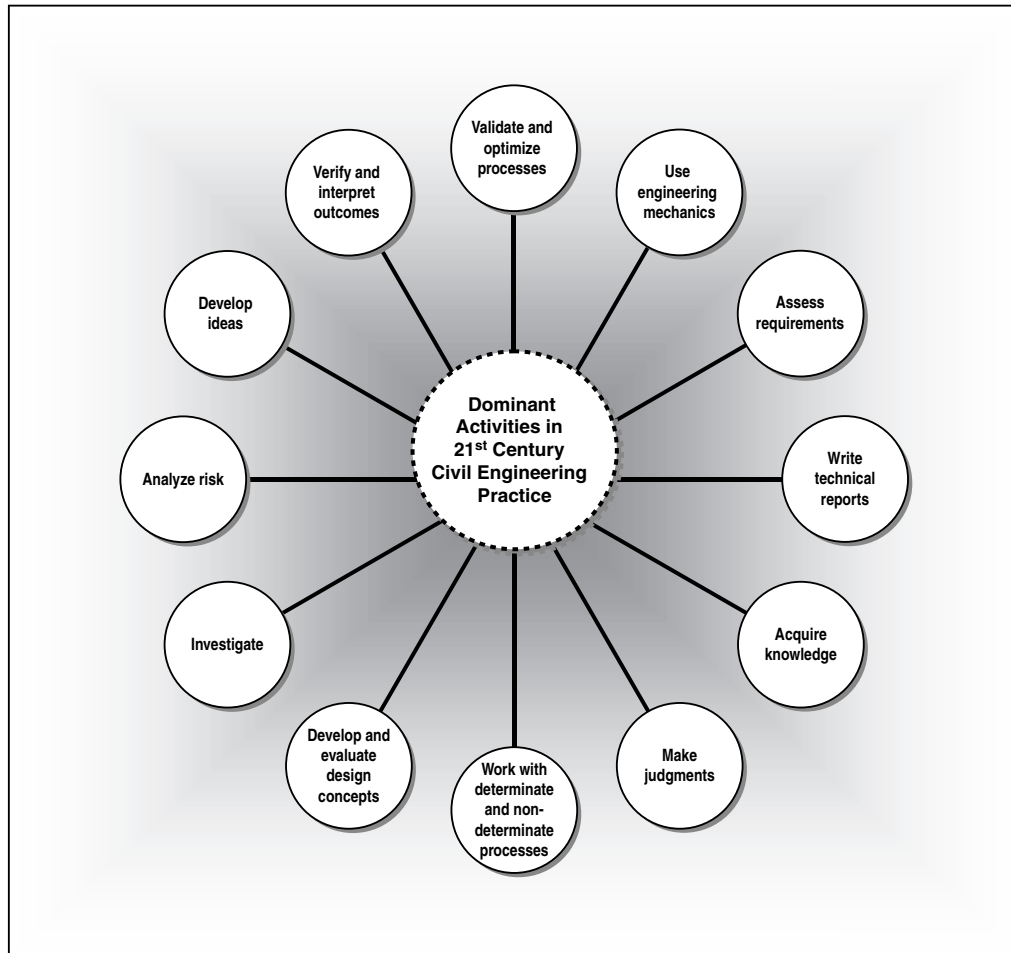
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Figure 1.2 Dominant activities in 21st century practice
 (Source: Dr. Iain A. MacLeod, Department of Civil Engineering, Strathclyde University, Glasgow, Scotland)

READERS' GUIDE

Of the 24 outcomes discussed in BOK2, this book addresses the following:

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- | | |
|---|---|
| 8. Problem Recognition and Solving | 17. Public Policy |
| 9. Design | 18. Business and Public Administration |
| 10. Sustainability | 19. Globalization |
| 11. Contemporary Issues/Historical Perspectives | 20. Leadership |
| 12. Risk and Uncertainties | 21. Teamwork |
| 13. Project Management | 22. Attitudes |
| 16. Communication | 23. Lifelong Learning |
| | 24. Professional and Ethical Responsibility |
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The *Civil Engineer's Handbook of Professional Practice* offers additional relevant information such as: the design professional's role in the project development process; the legal infrastructure in the United States; the fundamental contents of contracts; the origin of conflicts; the various roles that the civil engineer plays in construction projects; how the legal world views construction disputes; the basic economics of civil engineering practice; and emerging technologies relevant to civil engineering. Each chapter concludes with references for further reading and or study.

The book presents information in three levels of increasing detail through the use of graphics (photographs, illustrations, line drawings, graphs, text boxes, and cartoons) and text. These illustrations form one level of information, the commentary included in text boxes forms another, and the third is the actual text. The first page of each chapter outlines the key concepts presented and contains a unique graphic that helps to orient the reader.

The chapters of the *Civil Engineer's Handbook of Professional Practice* can be read in the order that best suits the reader. Following is a brief summary of the chapters and appendices:

- Chapter 1—Introduction
This chapter addresses the overall issues outlined in the ASCE's Body of Knowledge, first and second editions (BOK1 and BOK2) and the need for a new approach to civil engineering.
- Chapter 2—Background and History of the Profession
This chapter covers BOK2 Outcome 11—Historical Perspectives and gives an overview of the Architectural/Engineering/Construction (AEC) industry.
- Chapter 3—Ethics
This chapter covers BOK2 Outcome 24—Professional and Ethical Responsibility.
- Chapter 4—Professional Engagement
This chapter covers BOK2 Outcome 8—Problem Recognition and Solving.
- Chapter 5—The Engineer's Role in Project Development
This chapter covers BOK2 Outcome 9—Design.
- Chapter 6—What Engineers Deliver
This chapter covers BOK2 Outcome 8—Problem Recognition and Solving and Outcome 9—Design.
- Chapter 7—Executing a Professional Commission
This chapter covers BOK2 Outcome 13—Project Management.
- Chapter 8—Permitting
This chapter covers BOK2 Outcome 17—Public Policy.
- Chapter 9—The Client Relationship
This chapter covers BOK2 Outcome 18—Public Administration.
- Chapter 10—Leadership

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This chapter covers BOK2 Outcome 20—Leadership and Outcome 21—Teamwork.

- Chapter 11—Legal Aspects of Professional Practice
This chapter covers BOK2 Outcome 12—Risks and Uncertainties as well as the additional legal aspects.
- Chapter 12—Managing the Civil Engineering Enterprise
This chapter covers BOK2 Outcome 18—Business Administration.
- Chapter 13—Communicating as a Professional
This chapter covers BOK2 Outcome 16—Communication.
- Chapter 14—Having a Life
This chapter covers BOK2 Outcome 22—Attitudes and Outcome 23—Lifelong Learning.
- Chapter 15—Globalization
This appendix covers BOK2 Outcome 19—Globalization.
- Chapter 16—Sustainability
This appendix covers BOK2 Outcome 10—Sustainability.
- Chapter 17—Emerging Technologies
This appendix covers a primary concern identified in BOK2.

SUMMARY

The demands of society and the related high standards required by both ABET and ASCE present civil engineers and civil engineering educators with numerous challenges. The authors hope that the *Civil Engineer's Handbook of Professional Practice* will provide both aspiring and practicing civil engineers, as well as civil engineering educators, with useful information that assists them in meeting the needs of society and achieving their own personal goals.

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