Civil Engineering Practice in the Twenty-First Century

Knowledge and Skills for Design and Management

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Abstract: In addition to designing, building, and managing the constructed environment, civil engineers have important environmental management responsibilities. To succeed in these tasks, civil engineers must possess both management skills and technical tools. The Accreditation Board for Engineering and Technology, studies of the civil engineering work force, and engineering practitioners confirm the need for such skills and tools. The 12 chapters that comprise this book will assist students in developing those skills and prepare practitioners for the civil engineering challenges of the twenty-first century. Chapters discuss such topics as civil engineering heritage and future, consequences of civil engineering, work and careers in civil engineering, engineering design and the infrastructure life cycle, management, critical thinking, communications, government, finance and economics, law, and professional practice and ethics.

Cover photo of highway construction is courtesy Colorado Department of Transportation, 1999; photo by Gregg Gargan.

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Foreword

In contributions to society, civil engineers are hard to beat. They plan, design, construct, operate, maintain, and rebuild infrastructure and environmental systems that are critical to the survival of the human race and vital ecologic systems. Yet at the beginning of the twenty-first century, civil engineers find that their technical skills must be supplemented more than ever by other skills such as critical thinking, communications, and management.

This point has been driven home for us by civil engineers with years of experience as well as by graduates just entering the work force. What we are hearing is echoed in other places as well, including work force studies, university core curriculum advances, visiting practitioners, and the Accreditation Board for Engineering and Technology. Other professionals who seek to stay current are experiencing the same pressures.

In responding to this clear need for skills that extend beyond the technical arena, we have found that the most critical to practice today are thinking, management, and communications skills. This places us on the horns of a dilemma—does each student take a single course in a subject such as critical thinking, or should critical thinking be infused into all courses in the curriculum? We argue that the latter is the only feasible route, and we have introduced an integrated curriculum to bring the critical skill areas into learning about civil engineering.

This book presents our approach to the integration of essential skills into the civil engineering curriculum. It does not include many of the technical areas but can be used alongside technical textbooks to

guide students and practicing civil engineers in updating and broadening their capabilities with the skills they need to succeed in the twenty-first century.

This text derived from courses given in the Department of Civil Engineering at Colorado State University. We would like to thank Ms. Bernadette Shepard, who helped with administrative work, and the department faculty and students who contributed ideas and materials. Mike Kuyper, one of our students in 1998–1999, contributed the art work for Figure 1-1.

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Introduction

Although civil engineering will continue to be a vibrant and rewarding profession into the twenty-first century, the type of work associated with the profession will change dramatically. Rapid technologic and population growth as well as increasing environmental concerns will shape both the profession and individual careers. How civil engineers respond and adapt to these and other challenges will determine the vitality of the profession as a whole as well as individual success.

All professions add to the mix of human effort, enabling us to survive and progress. Likewise, every profession will be subject to change in the future, and each group must undergo self-examination to adapt successfully. What will civil engineering be like in 50 years? Technology has progressed so rapidly that engineering practice is much different today than it was even 2 decades ago. Social change has also been dramatic, and changing mixes of government and privatization influence our work. There is much to do that requires adjustments in how we are educated. Although such basic skills such as graphics, computation, and analysis will still be required, civil engineers will be expected to do much more in the future.

Civil engineering educators receive a great deal of advice from alumni and practitioners. Some of the most often repeated sentiments include the following: "Keep teaching the basics, but send us graduates who can communicate better, who understand the business world, and

who know something about finance," and "Don't neglect technical subjects, but the most important thing is that your graduates think clearly and exercise good decision-making skills." Such comments suggest that there is much more to civil engineering practice than technical knowledge. Accrediting agencies also know this and have developed a certification process for engineering programs to validate a broad education.

This book was written in response to the many suggestions we have received about civil engineering education. It outlines how the profession is changing and how students can prepare for such change. We hope it will be a helpful companion for civil engineering students and practitioners who navigate the shoals of constantly changing opportunities and challenges. This book results from practitioners' answers to the question of what should civil engineering students be taught. The answer is that civil engineering students should be taught many subjects that go beyond the standard engineering curriculum.

It is impossible for a 4-year engineering program to include courses covering every subject students may need or want. Our approach is to integrate these topics into other courses during the B.S. program. This method provides preparation for life, which requires dealing with many situations simultaneously. Civil engineers have two main roles: building and managing infrastructure and sustaining environmental resources. Carving out meaningful careers in these arenas while also adapting to change will be an exciting and potentially rewarding challenge.

Civil Engineering in the Twenty-First Century

What will civil engineering work be like in the twenty-first century? Civil engineers can look forward to being involved in society's most important problems. Figure 1-1 shows the six primary infrastructure systems that impact civil engineering work as well as the impact of civil engineering on society and the natural environment. These infrastructure systems are discussed in depth throughout this text.

Some forecasts about future work, such as those listed in the 1987 publication *Workforce 2000*, accurately predicted today's conditions (Johnston and Packer 1987): (1) The economy would be strong; (2) manufacturing would shrink as a percentage of the economy but would not wither away; (3) the work force would grow slowly and consist of older people, more women, and more minorities; and (4) jobs in service industries would require new skill levels.

Workforce 2020, published in 1997, predicts that the pace of technologic change will grow, the rest of the world will matter more to the United States, America will get older, and the labor force will continue its ethnic diversification (Judy and D'Amico 1997). These predictions are clear and appear to be accurate. The impact of these trends on civil engi-

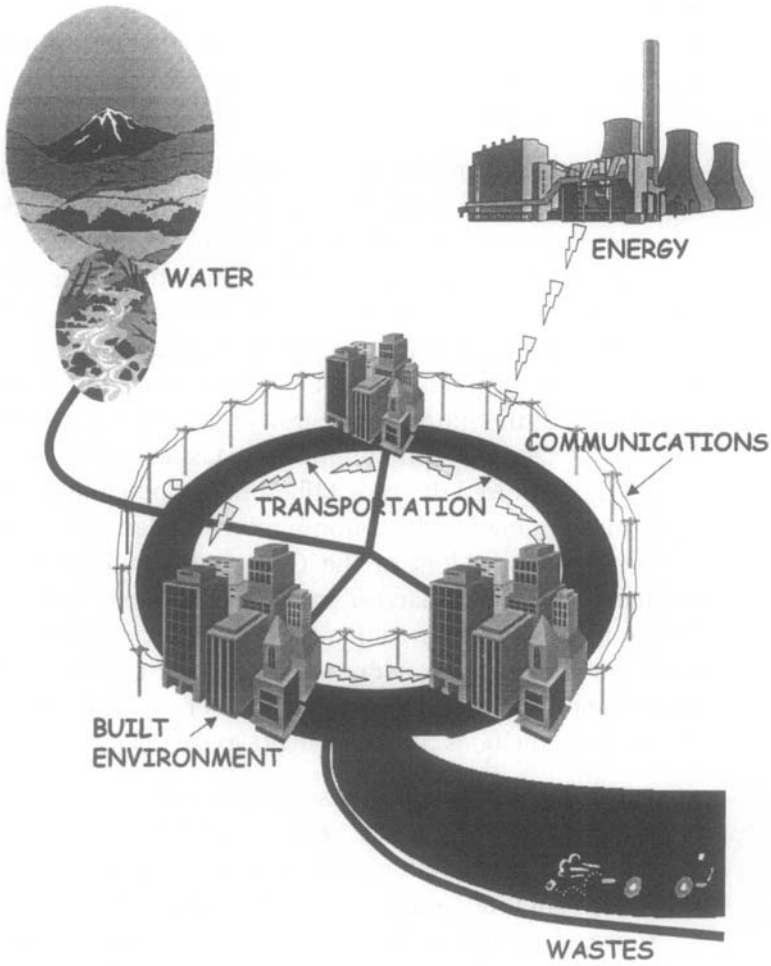

Figure 1-1 Civil infrastructure systems.

neering careers, including how to adapt new technologies to infrastructure systems, how to adapt to the global environment, and how to respond to a more diverse working environment, are discussed throughout this book.

Civil engineers must adapt all available information about professional trends and career advice, including trends published by the Career Center at the University of Waterloo, Canada (University of Waterloo 1997):

- The workplace is changeable.
- The job market is dynamic and changeable.
- Positions will be less stable, and lifetime employment will end.
- Organizations do not take responsibility for employee development.
- Individuals must take responsibility for their careers.
- Downsizing and delayering will reduce promotion opportunities.