



# **MATERIALS FOR CIVIL AND CONSTRUCTION ENGINEERS**

SECOND EDITION

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# PREFACE

A basic function of civil and construction engineering is to provide and maintain the infrastructure needs of society. The infrastructure includes buildings, water treatment and distribution systems, waste water removal and processing, dams, and highway and airport bridges and pavements. Although some civil and construction engineers are involved in the planning process, most are concerned with the design, construction, and maintenance of facilities. The common denominator among these responsibilities is the need to understand the behavior and performance of materials. Although not all civil and construction engineers need to be material specialists, a basic understanding of the material selection process, and the behavior of materials, is a fundamental requirement for all civil and construction engineers performing design, construction, and maintenance.

Material requirements in civil engineering and construction facilities are different from material requirements in other engineering disciplines. Frequently, civil engineering structures require tons of materials with relatively low replications of specific designs. Generally, the materials used in civil engineering have relatively low unit costs. In many cases, civil engineering structures are formed or fabricated in the field under adverse conditions. Finally, many civil engineering structures are directly exposed to detrimental effects of the environment.

The subject of engineering materials has advanced greatly in the last few decades. As a result, many of the conventional materials have either been replaced by more efficient materials or modified to improve their performance. Civil and construction engineers have to be aware of these advances and be able to select the most cost-effective material or use the appropriate modifier for the specific application at hand.

This text is organized into three parts: (1) introduction to materials engineering, (2) characteristics of materials used in civil and construction engineering, and (3) laboratory methods for the evaluation of materials.

The introduction to materials engineering includes information on the basic mechanistic properties of materials, environmental influences, and basic material classes. In addition, one of the responsibilities of civil and construction engineers is the inspection and quality control of materials in the construction process. This requires an understanding of material variability and testing procedures. The atomic structure of materials is covered in order to provide basic understanding of material behavior and to relate the molecular structure to the engineering response.

The second section, which represents a large portion of the book, presents the characteristics of the primary material types used in civil and construction engineering: steel, aluminum, concrete, masonry, asphalt, and wood. Since the discussion of concrete and asphalt materials requires a basic knowledge of aggregates, there is a chapter on aggregates. Moreover, since composites are gaining wide acceptance among engineers and are replacing many of the conventional materials, there is a chapter introducing composites.

The discussion of each type of material includes information on the following:

- Basic structure of the materials
- Material production process
- Mechanistic behavior of the material and other properties
- Environmental influences
- Construction considerations
- Special topics related to the material discussed in each chapter

Finally, each chapter includes an overview of various test procedures to introduce the test methods used with each material. However, the detailed description of the test procedures is left to the appropriate standards organizations such as the American Society for Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO). These ASTM and AASHTO standards are usually available in college libraries, and students are encouraged to use them. Also, there are sample problems in most chapters, as well as selected questions and problems at the end of each chapter. Answering these questions and problems will lead to a better understanding of the subject matter.

There are volumes of information available for each of these materials. It is not possible, or desirable, to cover these materials exhaustively in an introductory single text. Instead, this book limits the information to an introductory level, concentrates on current practices, and extracts information that is relevant to the general education of civil and construction engineers.

The content of the book is intended to be covered in one academic semester, although quarter system courses can definitely use it. The instructor of the course can also change the emphasis of some topics to match the specific curriculum of the department. Furthermore, since the course usually includes a laboratory portion, a number of laboratory test methods are described. The number of laboratory tests in the book is more than what is needed in a typical semester in order to provide more flexibility to the instructor to use the available equipment. Laboratory tests should be coordinated with the topics covered in the lectures so that the students get the most benefit from the laboratory experience.

The first edition of this textbook seemed to serve the needs of many universities and colleges. Therefore, the second edition is more of a refinement and updating of the book, with some notable additions. Several edits were made to the steel chapter to improve the description of heat treatments, phase diagram, and the heat-treating effects of welding. Also, a section on stainless steel was added, and current information on the structural uses of

steel was provided. The cement and concrete chapters have been augmented with sections on hydration-control admixtures, recycled wash water, silica fume, self-consolidating concrete, and flowable fill. When the first edition was published, the Superpave mix design method was just being introduced to the industry. Now Superpave is a well-established method that has been field tested and revised to better meet the needs of the paving community. This development required a complete revision to the asphalt chapter to accommodate the current methods and procedures for both Performance Grading of asphalt binders and the Superpave mix design method. The chapter on wood was revised to provide information on recent manufactured wood products that became available in the last several years. Also, since fiber reinforced polymer composites have been more commonly used in retrofitting old and partially damaged structures, several examples were added in the chapter on composites. In the laboratory manual, an experiment on dry-rodded unit weight of aggregate that is used in portland cement concrete (PCC) proportioning was added and the experiment on creep of asphalt concrete was deleted for lack of use.

In addition to the technical content revisions, there are over 100 new figures to display concepts and equipment. Multiple sample problems and homework problems have been added to each chapter to allow professors to vary assignments between semesters.

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