BOOK REVIEWS

Materials for Marine Systems and Structures

Reviewed by H. S. Reemsnyder, Senior Research Fellow, Steel Products, Homer Research Laboratories, Bethlehem Steel Corporation, Bethlehem, PA 18016.

REFERENCE: *Materials for Marine Systems and Structures*, D. F. Hasson and C. R. Crowe, Eds., Academic Press, New York, 1988, 480 pages. *Materials for Marine Systems and Structures* is Volume 28 in the Academic Press series *Treatise on Materials Science and Technology*. Sixteen authors associated with marine systems and structures have contributed nine articles that stress the interaction of the marine environment, materials, and structural design. The objective of the treatise is to integrate the environmental data of ocean science, materials science, and structural intregrity principles for application to offshore structures and ships. The intended audience is practicing engineers and scientists, and graduate students in ocean and marine engineering and naval architecture.

The treatise begins with an overview on the theme of materials performance in marine systems and structures. Types and design aspects of, and materials selection for, marine structures are outlined. The welding process, fatigue resistance of weldments, corrosion fatigue of weldments, and the seawater corrosion of reinforced concrete are touched on briefly.

Aspects of the marine environment are discussed in three articles: environment, biofouling, and corrosion. The statistics and forces of wind and waves, formation, mechanical properties, and forces of ice, and the chemical and biological characteristics of seawater are presented in one article. Another article discusses the agents, formation, and control of marine micro and macrofouling. Forms of corrosion, the corrosive zones of the ocean environment, and factors affecting the corrosivity of seawater are the subjects covered in the third article; the corrosion behavior of metals and their alloys is emphasized.

The remaining five articles address the design aspects of marine structures. Materials selection, coatings, and cathodic protection for corrosion control are detailed. An extensive overview of materials selection includes the response of materials in the surface, near-surface, and deep ocean environments, and *in situ* evaluation of material performance. Concrete marine structures are presented in light of their materials, design, durability, and construction. The materials for mooring systems include chain, steel wire and synthetic fiber ropes, and steel tubular tendons. Fatigue, fracture, wear, and inspection of mooring lines are outlined. The concluding article addresses the insurance of structural integrity of marine structures through fracture control practices. All elements of current fracture control plans (material selection, testing, design, construction, operation, and inspection) are acknowledged.

The book, primarily a reference, surveys existing knowledge and leads the reader to papers in the open literature through almost 670 references. However, some sources are secondary rather than primary.

The two general areas—marine environment and structural design (including material performance and selection)—are given about equal coverage. However, the article on corrosion is the largest, with about 20% of the pages and figures, 30% of the tables, and 50% of the references. On the other hand, a topic of serious and regular concern in the design and operation of marine structures—fatigue—is given only 5% of the text and figures.

The contents of the book address the intended audience and are, in general, up-to-date, comprehensive, and accurate. However, the reviewer detected a few minor shortcomings. Some examples follow:

- The 13th edition of the American Petroleum Institute's "Recommended Practice for Planning, Designing, and Construction of Offshore Platforms," API RP-2A, 1982, is referenced. However, the document is now in the 18th edition and contains many important changes.
- The "hot-spot" stress approach to fatigue of weldments was developed originally for large, tubular connections in offshore platforms and is used widely today for the fatigue design of complex weldments. However, only one page is devoted to this subject and then primarily from a stress-analysis viewpoint.
- Another topic of significant, continuing, and costly interest to designers of marine structures is the occurrence of local brittle regions in the heat-affected zones of weldments in marine structures. This topic is not addressed anywhere in the treatise.
- An early version of the failure assessment diagram, a graphical approach to the elastic-plastic failure analysis of a structural component, is presented but is not really applicable to the structural steels used in marine structures. The current forms of the failure assessment diagram that are useful to designers are not covered.
- It is stated that 145 of the 2500 Liberty ships built during World War II broke in two and 700 experienced failures. Actually, by April 1953, 145 Liberty ships suffered Class 1 fractures (those in which the main hull was weakened, and the vessel lost or in dangerous condition), while about 700 suffered Class 2 fractures (fracture in a potentially dangerous location). Of the 2700 Liberty ships and 500 T-2 tankers built during World War II, 11 broke in two.
- The Miner-Palmgren cumulative damage rule and the fracture mechanics model of fatigue crack growth are presented as alternative analytical models for fatigue life assessment. Actually, they are complementary.
- The reader could infer from the treatise that J-integral and CTOD toughness estimates may be used to compute the critical combination of applied stress and crack size through a simple conversion to linear elastic stress intensity factor. Such an inference may lead to an unconservative conclusion. Instead, J-integral and CTOD are estimates of the elastic-plastic fracture toughness and serve as input to elastic-plastic failure analysis such as the aforementioned failure assessment diagram.

The book is amply illustrated with 63 tables and 137 figures. The table of contents gives the reader a very good indication of the scope of the treatise and the topics covered. However, the index may not be sufficient to assist the reader in finding a particular topic of interest. For example, one page is devoted to

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each of two topics (hot-spot stress and fatigue of chain links) but neither item is listed in the index.

Mechanical Testing

Reviewed by Jack H. Westbrook, Principal Consultant, Sci-Tech Knowledge Systems, Scotia, NY 12302.

REFERENCE: *Mechanical Testing*, I. Curbishley, Ed., Institute of Metals, London, and Institute of Metals, North American Publication Center, Brookfield, VT, 357 pp., 1988.

This work is the third in a series of seven monographs on the Characterization of High Temperature Materials under the general editorship of M. McLean. Prior volumes related to microstructural and chemical characterization. The present volume represents the proceedings of a December 1988 seminar, sponsored and organized by the Institute of Metals through its committees on Materials Science, Materials Engineering and Continuing Education. The targeted audience is the nonspecialist who needs to know what types of tests are available, how to select the test most appropriate for his purposes, and who needs to have an appreciation of the methods of determination and analysis of the data he uses and knowledge of the status of national and international standards. As the editor points out, while the emphasis is on high temperature materials, the techniques and principles are applicable to many different material classes, and not all tests relevant to high temperature materials are conducted at high temperatures.

Six particular subject areas are addressed: tensile testing by T. G. F. Gray, Creep Testing by M. S. Loveday, Fatigue Crack Growth by R. P. Skelton, High Strain (Low Cycle) Fatigue by G. Sumner, High Cycle Fatigue by R. W. Suhr, and Fracture Toughness by E. Morland. Though all the authors are from British university, government, or industrial laboratories, the work is not at all parochial. Extensive reference and discussion are made to other national and international testing standards as well as to various ASTM publications. The articles are all well-written and extensively referenced and illustrated. In general, the aim is to include representative, not exhaustive, review and citation of the literature. It is notable that nearly all the authors indicate appreciation for the historical development of the field by citing some pioneering contributions from the Renaissance to near-modern times.

In accordance with the major objective of the series, more than half of the text is devoted to descriptive and prescriptive discussion of mechanical testing methods. Standards and data receive relatively less attention and are completely ignored by Suhr in an otherwise excellent essay. Only enough theory of mechanical behavior and physical metallurgy is included to enable understanding of the design and application of test methods. The skilled hand of the editor, I. Curbishley of UKAEA, is evident in the cross-referencing between chapters, in the quality of the author-prepared typescripts, and in his own contribution on crack growth during creep. Regretably, Curbishley did not see fit to add an index.

The discussions on standards for mechanical testing cover: comparisons between British, European, American, and International Standards; observations of standards missing or only now under development; notation of parameters needed but not specified in current standards or methods for their control when not defined; the accuracy to be expected from test data if all provisions of current standards are met; the criteria for choice of a particular test standard in a given application area; and the tie between test standards (and the resulting data) and design codes.

Although most chapters contain some treatment of test data, particularly their accuracy and areas of application, much more might have been said about pertinent methods of data analysis, modelling, and extrapolation techniques. The most egregious omission (which will frustrate both the mechanical designer and the test developer who seeks some reliable data for comparison) is the failure to list key data compilations, either printed or computerized, in each topical area. Tabular compilations and graphical compendia (so-called atlases) exist on both sides of the Atlantic, put out by such reputable organizations as ESDU, British Steel, DoD, SAE, and MPC, as well as ASTM in its Data Series publications.

The book succeeds well in its effort to provide a readily comprehensible overview of mechanical testing for the nonspecialist. It is unfortunate that, despite the "Materials" of the series title, the present work is devoted almost exclusively to metals; yet ceramics, polymers and composites are well known to pose special testing problems of their own. While the particular test methods chosen for discussion are clearly the most important, a more comprehensive coverage would have included treatment of hot hardness, formability/workability, and stress relaxation.

Adequate reference is provided in each of the chapters to specialized monographs, conference proceedings, and encyclopedic treatises in that topical area. However, a reader wishing a broad, contemporary, but more in-depth coverage of the same scope and quality as the present volume should be directed to Loveday, Day, and Dyson, "Measurement of High Temperature Mechanical Properties of Materials," (HMSO, 1982) or to "Mechanical Testing" (1985), Vol. 8 of ASM's *Metals Handbook*; the latter is not even mentioned.

In sum, we have here a valuable, up-to-date, concise, but incomplete treatment of the subject field which will be useful to those developing and using standards and those doing mechanical testing.