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Chapter I-4
The Coastal Engineering Manual

I-4-1. Background

During the 1970s, ‘80s, and ‘90s, coastal engineering practice by the U.S. Army Corps of Engineers (USACE) and standard engineering for most coastal projects throughout the world have been based, wholly or in part, on the *Shore Protection Manual (SPM)*. Since the *SPM* was last updated in 1984, the coastal engineering field has witnessed many technical advances and increased emphasis on computer modeling, environmental restoration, and project maintenance applications. The BEB produced the first standardized guidance on coastal structure design in 1954, *Shore Protection Planning and Design*, also known as *TR-4*. This was the forerunner of the *SPM* that was first published by CERC in 1973, and revised in 1975, 1977, and 1984. These documents present the methodology that guided coastal structure and beach fill design for most of the projects constructed to date. The USACE traditionally is responsible for constructing and maintaining United States Federally authorized coastal civil works projects including harbor entrance channels, navigation channels and structures, coastal storm damage reduction and shore protection projects. Therefore, the USACE is primarily responsible for developing the principles of coastal engineering as they are practiced in the United States.

a. Shore Protection Planning and Design, TR 4. The methodologies of *TR-4* emphasized designing coastal structures for stability against wave forces. The technology available at that time provided little means to address the functional performance of structures, nor provide any guidance for predicting the performance or stability of a beach fill. Beach and dune design was only qualitatively addressed. Simple linear wave theory, static terrestrial structural engineering principles, and trail-and-error experiential data were used to develop the empirical relationships and rules-of-thumb presented in *TR-4*. Beach fills of this era were not usually designed to perform a particular function, but were typically placed as an added feature to increase the sediment supply in the area of interest and to reduce wave energy striking the protective structures (the primary project feature).

b. Shore Protection Manual, SPM. The *SPM* was a significant advancement over *TR-4* in that it used the results of physical model tests to develop principles of wave-structure interaction, advancements in wave theory, and statistics and other data from various projects. The *SPM* provided significantly more guidance in the positioning and intent of groins and breakwaters, predicting the flood control benefits of seawalls, and predicting the stability of beach fills. At 1,160 pages, the first edition of the *SPM* was almost three times the length of the 20-year-older *TR-4* (Camfield 1988). The *SPM* and beach fill projects of the 1970s and early ‘80s were designed around the objective of beach erosion control and recreational use. The quantity of material to be placed was computed based on the long-term recession rates, and the amount of surface area desired to support recreational needs. The *SPM* presented guidance to assist in predicting maintenance nourishment quantities based on the grain size of the placed fill and its projected stability relative to the native material grain size. Neither the *SPM* nor the projects constructed during this time concerned themselves with the performance of the beach fill template during a particular storm. At that time, beach fills were not usually designed with a primary purpose of providing flood control benefits.

The *SPM* is commonly used as a university textbook and as a training aid for apprentice engineers. It is also a convenient reference for empirical procedures to compute a particular design parameter. Approximately 30,000 copies have been sold through the U.S. Government Printing Office. Translations into other languages, including Chinese and Catalonnian (Spanish), further attest to the *SPM’s* role as an international standard guidance for professional coastal engineers (Pope 1993, 1998). Even though the *SPM* is a general

coastal engineering reference, some aspects of navigation and harbor design are not included and its primary focus is shore protection.

c. Coastal Engineering Manual, CEM. The advent of numerical models, reliable field instrumentation techniques, and improved understandings of the physical relationships which influence coastal processes lead to more sophisticated approaches in shore protection design in the later 1980s and 90s. Numerous guidance and analytical tools have been developed over the last 15 years to assist the coastal engineer in predicting not only the stability of a beach fill, but also its performance during extreme events. Cross-shore and alongshore change models, hydrodynamic hind cast data bases, and stochastic statistical approaches have been developed to provide the practicing coastal engineer with procedures for quantifying the flood control benefits of a proposed design. The functional interaction of beach erosion control structures (i.e., groins and breakwaters) can be analyzed with numerical simulation. Seawalls can be designed not only for stability, but also physically modeled to predict various elements of the wave-structure interaction including scour and overtopping. A "modern" technical document incorporating all the tools and procedures used to plan, design, construct, and maintain coastal projects was needed. The USACE tasked the Coastal Engineering Research Center and, later, the Coastal and Hydraulics Laboratory with producing a new reference incorporating established science and much of this new technology, to be called the *Coastal Engineering Manual (CEM)*. Included in the *CEM* are the basic principles of coastal processes, methods for computing planning and design parameters, and guidance on how to develop and conduct studies in support of coastal storm damage reduction, shore protection, and navigation projects. Broader coverage of all aspects of coastal engineering are provided, including new sections on navigation and harbor design, dredging and dredged material placement, structure repair and rehabilitation, wetland and low energy shore protection, cohesive shores, risk analysis, numerical simulation, the engineering process, and other topics.

I-4-2. Structure

The *CEM* contains two major subdivisions: science-based parts and engineering-based parts. The science-based parts include "Part II - Coastal Hydrodynamics," "Part III – Coastal Sediment Processes," and "Part IV – Coastal Geology." These provide the scientific foundation on which the engineering-based parts rely.

a. Part II. "Coastal Hydrodynamics" is organized to lead the reader from the fundamental principles of linear and other wave theories, including irregular waves and spectral analysis, to ocean wave generation and through the process of transformation as the wave approaches and reacts with the coastline. Analysis of water level variations including astronomical tides and storm surges are presented along with the hydrodynamics of coastal inlets and harbors are included in other chapters.

b. Part III. "Coastal Sediment Processes" includes chapters on sediment properties, along shore and cross-shore transport, as well as chapters on wind transport, cohesive sediment processes and shelf transport.

c. Part IV. "Coastal Geology" includes chapters on terminology, geomorphology, and morphodynamics.

The two engineering-based parts, Part V – "Coastal Project Planning and Design" and Part VI – "Design of Coastal Project Elements" are oriented toward a project-type approach, rather than the individual structure design approach that characterized the *SPM*. The architecture and substance of the engineering-based parts is the result of an internationally-attended workshop in February 1994. A logical systems-based approach is used for the engineering structure of the *CEM*. This mirrors the engineering process with guidance in

selecting and using various planning and design tools as appropriate for the project at hand. The engineering tools are presented in a modular grouping to allow for future updates as the technology continues to advance.

d. Part V. "Coastal Project Planning and Design" starts with chapters discussing the planning and design process and site characterization. Following these general chapters are ones discussing the planning and design of shore protection projects (including coastal armoring, beach restoration, beach stabilization and coastal flood protection projects), beach fill, navigation projects (including defining the fleet, entrance channel, inner harbor elements, structures, sedimentation, maintenance, and management), and environmental enhancement projects (including laws, regulations, and authorities, issues, alternative approaches, planning, and design). A final chapter outlines conditions and regulations unique to USACE projects in the United States.

e. Part VI. "Design of Coastal Project Elements" includes chapters discussing philosophy of coastal structure design, the various types and function of coastal structures, site conditions, materials, design fundamentals, reliability, and the design of specific project elements (including a sloping-front structure, vertical-front structure, beach fill, floating structure, pile structure, and a pipeline and outfall structure.

f. Appendix A. The "Glossary of Coastal Terminology" has been compiled from numerous sources and lists terms found throughout the CEM. Note that there is no single, comprehensive list of mathematical terms and symbols. Each CEM chapter has its own symbol list.

g. Updates. The CEM is intended to be a "living document" and to be updated periodically as advances in the field render the existing chapters obsolete or inadequate. Comments and suggestions should be addressed to the Coastal and Hydraulics Laboratory, CEERD-HN-CE. Corrected or modified chapters will be posted on the CHL web page.

I-4-3. References

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I-4-4. Acknowledgments

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