MARINE STRUCTURES AND MATERIALS

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Keywords: Marine structures, design criteria, steel, concrete, rock and sand, fixed structures, movable structures, complimentary structures, coastal structures, offshore structures, and deep-water structures.

Contents

Summary

Marine structures are various kinds of engineering facilities, which are constructed and installed in the ocean for marine resource exploitation and continuous development. The marine engineering structures can be divided into three types: fixed structures, movable structures and complimentary structures. These types of structures can be categorized according to their usage, material and supporting system. Conventional materials, such as steel, concrete, sand, rocks etc., are commonly used. The high strength concrete, pre-stressed concrete, antifreeze concrete, light weight concrete become more popular; also new composite materials, such as high strength plastic material and their production, have shown their high quality.

Because of the serious environmental loading exciting the marine structures, not only traditional static and dynamic analyses are required, but also the structure reliability analysis should be considered. Marine structures will suffer corrosion caused by chemical process, the collision by ships, and damage by unexpected disasters. The structural strength with such deterioration should be investigated and analyzed. Following an intensive utilization along coastal area development, deeper water region has gradually intrigued public attention. However, the environmental condition became more severe, and the investment became more expensive. For satisfying this kind requirement, the environmental condition should be determined more accurately and the design method should be improved as well.

1. Definition and Catalog of Marine Structures

Marine structures are engineering facilities constructed and installed in coastal zones or open oceans for the exploitation of various marine resources and the maintenance of its continuous operations. Generally, the marine structures can be divided into three types: fixed, movable (or floating structures) and complimentary structures. Fixed structures are fixed on the seabed on a long-term basis by using piles or the gravity of structures. They include gravity type breakwater, gravity type pier, groin, seawall, gravity concrete platform, jacket platform, submarine pipeline, submarine tunnel and various types of artificial island. Movable structures can be operated at different locations by the operation of fixing position, floating, sinking and removal. They include floating type breakwater, floating pier, jackup drilling platform, bottom-supported platform, semi-submersible platform and various types of specially designed boats etc. Complimentary structures are partially fixed by using guyed cable, tension facilities and universal joints to limit and control the six degrees freedom movement induced by various environmental forces.

To satisfy the operation requirements of orientation and movement of structures, complimentary structures are vertically anchored and often oriented by using flexible members. Complimentary structures include tension leg platform, guyed tower platform, and articulated tower platform etc.

According to the functions and characteristics of marine structures, marine structures can be grouped into coastal, offshore and deep ocean structures.

A. Coastal Structures

(1) Breakwater: vertical wall breakwater, sloping structure breakwater, and composite type breakwater
(2) Piers: gravity type piers, pile foundation piers, and floating piers
(3) Seawalls: vertical wall seawall, sloping structure seawall, and composite type seawall
(4) Groins
(5) Tidal gate
(6) Submarine tunnel

B. Offshore Structures

(1) Fixed structures: jacket platform, tower type platform (spar platform), and gravity platform
(2) Movable structures: jack-up platform, bottom supported platform, semi-submersible platform, and floating drilling ship
(3) Complimentary structures: tension leg platform and guyed tower platform
(4) Mooring system facilities: single anchor leg mooring system and catenary anchor leg mooring system
(5) Submarine facilities: subsea pipeline, seabed wellhead template, and submarine tunnel
(6) Artificial islands: very large floating structures, and gravity type artificial islands

C. Deep Ocean Structures

Deep sea manned submersible

2. Design Criteria and Methods for Marine Structures

2.1. General Requirement for the Design of Marine Structures

A good design of marine structures should consider the following requirements. They are utilization, safety, environmental protection, construction and economy.

A. Utilization:

The design of marine structures for the exploitation of marine resources, the protection of marine environment, and safety of marine activities should be first to match the utilization requirements. The utilization requirements include the function of marine structures, the environmental conditions for construction, and the operation lifetime of the structures. The type of structures should first be decided according to its utilization requirements.

B. Safety:

Usually the marine structures are constructed in the coastal zone or in the open seas, where the marine environmental conditions could be very severe. The marine structures and their members are required to meet its reasonable design criteria and safety level, as they go through the process of building, haulage, installation, operation and removal. Here, the reasonable design criteria and safety level mean that the structure is to be constructed or operated normally without causing damage under a specified probability. Additionally, the safety requirements for marine structures located far from coastal line should also include the safe evacuation and rescue process of operators during disaster, and the prevention of marine environment pollution. As for the design of structures for residential usages, the health condition of residents in marine environments should also be carefully considered.

C. Environmental Protection:

All governments in various countries pay great attention to protect marine environment from the impacts of marine structures. So the minimization of environmental impacts from marine structures should be an important design requirement for designers to follow, especially for those structures used for the exploitation of marine oil-gas resources. Proper treatments of disposals from both the production process and the human living activity are very important. Also, impacts of structure constructions on marine environments and living beings should be carefully considered.

D. Construction:

Construction requirements include sites, facilities and hardware for building process, the depth of waterway during marine transportation for structure and its members, sheltered

area, building scheduling, process for safety and protection of marine pollution. The construction requirement is an important factor for the choice of type and design option of structures, especially for the huge gravity concrete platform. The construction requirements could be is a decisive factor to the success or failure of design.

E. Economy:

Various design options can satisfy the same required functions of structure. The selection of a safer, more reliable and economic option as the final design is based on the technical and economical evaluations for various design options.

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Biographical Sketches

Professor Yu-cheng LI was born in Shanghai, China on December 20, 1932. He studied at Dalian Institute of Technology (now Dalian University of Technology) and graduated in Civil Engineering in 1953 with outstanding level. From August 1953 to February 1960, he was with the Department of Hydraulic Engineering, DIT, Dalian, China as an assistant and the director of Port Engineering Laboratory of DIT. From March 1960 to February 1980 he worked in the same department of DIT, Dalian, China as a lecture and still was the director of Port Engineering Laboratory. From March 1980 to February 1983 he became an Associate Professor of DIT, Dalian, China and the Vice-director of the Research Institute of Ocean Engineering of DIT. Between February 1981 and March 1982 he did research in the Department of Ocean Engineering in Texas A&M University, College Station, Texas, US as a visiting research scholar. Since February 1983 he was working for the Department of Civil Engineering, Dalian University of Technology, Dalian, China, as a professor. From October 1990 to October 1994 he was the Vice-director of State Key Laboratory of Coastal and Offshore Engineering in Dalian, China. From October 1994 to October 2004, he was the Vice-chair of the Academic Committee of the State Key Laboratory of Coastal and Offshore Engineering. From May 1992 to December 2001, he served as the Vice-chair (executive) of the Fishing Port Design and Construction Evaluation Committee of Ministry of Agriculture of Chinese Government. Professor Li is also a part-time professor of Shanghai Jiaotong University (since 1997), Dalian University of Fisheries (since 1991) and Dalian Institute of Naval Force (since 2001).

He was authored/coauthored six books. He is the Co-Editor of four international conference proceedings. He has authored/coauthored over 180 research papers. From 1996 to 1998 he severed on the Board of Directors of International Society of Offshore Engineers. He severs on the Editorial Boards of the following five journals, namely: China Ocean Engineering, Journal of Hydrodynamics, China Offshore Platform, The Ocean Engineering and Journal of Coastal Engineering. His research work has been awarded by the National Scientific Meeting, China in 1978 and by the National Scientific and Technological Prize of China (two silver prizes in 1986 and 2002, one bronze prize in 1999). More than ten of his research results have been adopted in the Design Specification of Port Engineering in China (from 1974 to 2004). He got PACOMS award in 1994 and ISOPE award in 1998 by the International Society of Offshore and Polar Engineering (ISOPE).

Professor Lin-pu LI was born in Liaoyang, Liaoning, China on July 28, 1941. He studied at Dalian Institute of Technology (now Dalian University of Technology) and graduated in Hydraulic Engineering from this Institute, Dalian, China in 1965 with first class. From December 1965 to July 1974, he was with the department of Hydraulic Department, DIT, Dalian, China as an assistant. From August 1975 to July 1990, he worked in the same department of DIT, Dalian, China, and he was a lecture. From August 1990 to July 1995, he became an Associate Professor of the Department of Civil Engineering, DIT, Dalian, China, and he served as the Director of Offshore Engineering Program in DUT, Dalian, China. Since July 1995, he is working as a full Professor of this university; also he was the Director of the Design Institute of Civil Engineering and Architecture of DUT, Dalian, China.

Professor LI engaged in teaching and research in the field of offshore engineering and marine oil-gas exploitation engineering for more than thirty years. He taught courses of 'Offshore Structures', 'Engineering Economics and Project Management' and 'Marine Environmental Loading' etc. He was the editor of the book entitled 'Offshore Jacket Platform' pressed in 1992 by China Ocean Press. Prof. LI published more than thirty papers related to marine oil-gas exploitation, foundation scour of marine structure and structure fatigue problem of marine platform.