RISK ASSESSMENT IN PORTS FACILITIES

I. RISK ANALYSIS IN MARITIME STRUCTURES THE SPANISH MARITIME WORKS RECOMMENDATIONS (Recomendaciones para Obras Marítimas. ROM)

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1. INTRODUCTION

Risk analysis in maritime structures is presented in general terms following the Spanish Maritime Works Recommendations. In these Recommendations, risk analysis takes into account the general concepts and numerical probabilistic tools (detailed in previous presentations) employed in what, strictly is, the risk analysis in structures. So, aspects related with development of alarm systems, contingency plans, applications of prevention techniques, dynamic feedback operations, and decisions-making, involved in the general context of Risk Management, are no considered. being,

The development of Maritime Works Recommendations (ROM Program) began 1987, by order of General Director of the Ports and Coast of the Ministry of Public Works and Urban Plan, with the creation of a technical Commission assigned to draw up a set of Recommendations or Technical Codes. These Recommendations or Codes would bring together the most advanced technology in the field of maritime and port engineering and became a technical instrument for project engineers, supervisors and builders, allowing both public administrator, and private companies interested in maritime engineering, easy access of this field of technology. From its beginning, ROM program was thought as a program in continuous evolution according to the new developments.

2. RISK ANALYSIS IN MARITIME STRUCTURES

The term *risk* comprises the probability of occurrence of an undesirable event (mainly the occurrence of wave's storm in maritime structure) and the consequences of the occurrence of that event. In formula form, risk can be expressed as the product of probability by consequences.

The goal of risk analysis is to obtain a structure, which, during its construction, and through its intended service life, has sufficiently low probability o failure or collapse. The three main elements of risk analysis are: hazards, mechanisms and consequences

A *mechanism* is defined as the manner in which the structure responds to hazards. A combinations of hazards and mechanism leads, with a certain probability, to failure or collapse of the structure as a whole of or its components, The boundary between failure and non failure or between collapse and non collapse is generally called a *state* differentiating among ***ultimate states*** (failure or collapse with regard to principal

functions), and ***serviceability states*** (failure with regards to reductions of other functions such as functional, durability or aesthetic activities)

Furthermore, due to, generally, maritime structures are built to protect goods and services from actions of the sea and atmosphere, it is not usually possible, mainly for economic reasons, to built maritime structures capable of operating under all prevailing meteorological and marine conditions. For these reasons, ROM 0.0, considers another state, referred as ***operational limit state,*** that makes possible to asses the temporal loss of operational capacity of the installation caused by actions of different physical agents prevailing upon structure but without the structural failed of any of its parts.

In assessing the safety, serviceability and operationally of structure it is very important to consider the system as whole. A structure, such as a breakwater, is composed of several components, each of which can be prone to many hazards and mechanism. The failure of some component may lead directly to failure of the system (series connection), or be compensating for one another (parallel connection).

A systematic method to include all likely failure mechanisms into one value for the failure probability (P_F) of the structure is the use of a ***failure tree***. By means of a failure tree, the first factor of the risk, the probability of failure, can be assessed rather objectively. However, an objective quantitative determination of losses or consequences is, in general, more subjective due to the environmental, social, and political aspect involved.

3. - GENERAL PROCEDURES IN MARITIME WORKS PROJECTS

The main objective of a maritime work project is to make possible the development of economic activities that could have repercussion in its immediate context. Consequently, project design should be reliable, with regards to its safety, serviceability, with regards to its function, and operational, with regards to its exploitation.

Maritime Works Recommendations, ROM 0.0-2001, gives a general procedure that includes different methods which help to evaluate if a project design alternative satisfied the safety, serviceability, and exploitation requirements in consonance with the recommended levels of reliability, functionality and operationally during specific periods of times.

The procedure is a guide for the verification of the whole maritime structure, each subset and its elements in all project phases and working and operating conditions.
The development of the limit state method and the corresponding failure and stoppage modes, which describe the cause, mechanism, way, etc, in which failure or stoppage of the subset occurs are defined. Sates related to reliability, and functionality through ultimate and serviceability states as well as those related to operationally, through operational stoppage limit state are also described.

Appropriate criteria for the organization of the projects factors and terms in final design equation are given on the basis of the simultaneity of the actions and the compatibility of the term values in consonance with the work and operation conditions.

Finally, methods for the calculation of the probability of occurrence of one or all of the modes failure are proposed.

The recommended methods include the deterministic approach, Level I, and the probabilistic methods known as Level II and Level III.

The former is recommended to evaluate the reliability, functionality, and operationally of the maritime structures with low economic social and environmental repercussions. Level II and III methods are required to verify project design alternatives with important social and environmental repercussions.

Theoretical concepts underlying to level II and III are briefly presented including criteria to study the overall probability of the structure as a system.

As Socioeconomic optimization criteria, ROM 0.0 propose the maximization of the objective function defined in terms of total cost/benefit of the subset of the structure and the total cost of the project, including its construction, stocks to improve the qualitative safety, insurance, corrective measures, financial cost, maintenance and the probable cost associated with the occurrence of failure. The optimization of the objective function can consider as many restrictions as desired, including the reliability, functionality and operationally, a maximum construction cost and annual maintenance cost.