InCom WG 140

Semi-Probabilistic Design Concept for inland hydraulic structures

Terms of Reference

Objective of the Working Group

The objective is to develop a plan for creating a Semi-Probabilistic Design Methodology for a Eurocode section on Hydraulic Structures.

Background

To better understand and mitigate the risks in their design, engineers are using semi-probabilistic methods for their designs of hydraulic structures. To date some engineering codes such as the American code Load and Resistance Factor Design (LRFD) and various design Eurocodes have progressed from a deterministic approach to a semi-probabilistic approach. The advantages of this switch are more efficient designs that better account for the risk into the designs of these structures. These designs should have uniform safety levels with better performance and durability since the uncertainties found in design and construction are better defined.

For the deterministic approach methods, the demand (load) and the capacity (strength) were both established according to recognized codes and practices. A single safety factor was used to check if the effects (usually in terms of stress and/or displacement) induced by the loads were less than the allowable.

Today, the deterministic approach is being replaced by the semi-probabilistic approach (as considered by the Eurocodes and LRFD) for which partial safety factors are applied on the loads (amplification factors) and on the strength (reduction factors). These factors are based on empirical knowledge and on the results of Level II and Level III probabilistic Models to represent uncertainty in loads and strengths and differ according to the considered limit state (performance requirement of the structure), the type of loads and the failure modes being examined.

The background of the semi-probabilistic approach is that each realization of the loads and the strength properties are stochastic or probabilistic in behavior. This means that each parameter (load and strength) has a mean or expected value (considered in the deterministic approach) but also a distribution function (e.g., normal, lognormal, etc.) usually characterized by a variance or standard deviation. The intersection of these distributions which is the probability of failure is assessed through the use of semi-probabilistic design code.

Return periods can be developed from the semi-probabilistic code to design structures to maintain a certain level of structural performance requirement. For this method, loads to which a structure will be subjected to during its service life, (i.e., water level, seismic, or vessel impact events) are defined using return periods or an annual probability. These return periods for loads are applied to the structure to minimize the probability of failure for the structure. Return periods depend on the Limit State under analysis (Ultimate Limit State, Serviceability Limit State, etc.)

Another large component of risk inherent in hydraulic structures is the probability of consequences, which can vary widely and can even change during the service life of a structure. Hydraulic structures may include everything from agriculture levees and remote navigation structures to flood control dams and levee systems situated just upstream of major population centers. Therefore, the probability of consequences can be coupled with the probability of failure to reach a societal tolerable level of risk.

Final Product

The objective is for this working group to come up with a plan to develop a semi-probabilistic design code specifically for hydraulic structures. The working group will develop practical solutions for several navigation and flood defence structures. This group will work in conjunction with WG 137 Navigation Structures' Resilience to Overloading which is developing requirements comparable to a building code for flood defence structures.

To facilitate acceptance by the design community and to aid in education, the report will include examples using both the deterministic and the semi-probabilistic procedures. The work effort of this group will be used to layout a plan for a future PIANC Working Group to come up with a formalized code for hydraulic structures using semi-probabilistic methods. This code can then be incorporated into the Eurocode and other codes for hydraulic structures.

This working group should work closely with others in the design community such as ICOLD, ASCE, ISO, etc. A future working group will be reasonable for developing the formalized code.

Matters to be Investigated

The report will compile design examples for navigation and flood defence structures. Some of the issues to be investigated include:

a. Defining loads (hydraulic, seismic, geotechnical, vessel impact, wind, uplift, etc.) and their distributions.
b. Defining strengths (steel, concrete, etc.) and their distributions.
c. Defining limit states for navigation and flood defence structures.
d. Developing semi-probabilistic reliability models and risk assessment methods.

Desirable Background or Experience of Working Group Members

The background and experience may include the following:

a. Civil, Geotechnical, Hydraulic, Hydrologic and Structural Design engineers, familiar with navigation and flood defence systems (River Engineering and/or Ports and Costal Engineering experience is welcome).
b. Persons familiar with the semi-probabilistic design codes and the concepts of reliability and risk.
c. Persons having a close relationship with the EUROCODE committees, other semi-probabilistic design code development committees or following associations ICOLD, ASCE, ISO.
d. A MarCom representative of WG 50 will be appointed to the Working Group.

RELEVANCE TO COUNTRIES IN TRANSITION

This working group can be useful to all PIANC members developing hydraulic structure infrastructure by providing a semi-probabilistic design code and examples for engineers to follow.