

STABILITY VERIFICATIONS OF MARITIME GRAVITY STRUCTURES: THE ITALIAN REFERENCE STANDARDS

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INTRODUCTION

The design of maritime structures in Italy (and in Europe) is not supported by current technical standards that deal specifically with criteria and methods for evaluating the meteoceanographic loads governing the design.

We refer specifically to port breakwaters or coastal defense structures involving gravity type structures, such as caisson breakwaters, concrete sea walls and rubble mound breakwaters.

For the design of these structures, like for building structures in general, the 2018 “Technical Standards for Constructions” (NTC 2018) edited by the Italian Ministry of Infrastructures and Transport do apply. These standards, however, do not specifically address the key aspects affecting the design of maritime structures.

Therefore, for marine engineering topics designers typically still refer to a specific standard dated back to 1996, the “Technical Instructions for the Design of Breakwaters” edited by the Italian Superior Council of Public Works (CSLLPP). While the 1996 Technical Instructions are still reliable guidelines for many aspects, they are not up-to-date and aligned with the limit state design method.

THE ITALIAN NORMS

The current Italian standards NTC 2018, very similar to Eurocodes, do provide methods for stability verifications of gravity type structures based on the limit state design method, which replaced the allowable stress method considered in the 1996 Technical Instructions.

The need to operate according to the limit state method, as provided in the most recent European and international standards, makes maritime engineers deal with lacks in the NTC 2018 concerning criteria and methods for evaluating loads induced by meteoceanographic loads.

Section 1.1 of the NTC 2018 mentions “...for matters not expressly specified herein, reference may be made to proven standards and other technical documents listed in Ch. 12.”, which include for instance the Eurocodes with related National Appendixes, the UNI and UNI EN norms. Also the instructions and guidelines published by the Italian Superior Council of Public Works are cited among the references of proven validity, but only where they are not in contrast with the contents of the NTC 2018. Hence, while other regulations are generally referred to for filling specific gaps in the NTC 2018, the absence of a unified, comprehensive standard poses challenges for engineers when it comes to systematically and clearly addressing the design and sizing of gravity-based maritime structures.

In the following we present two specific cases addressed in the design of the new offshore breakwater for the Port of Leghorn (mainly vertical composite breakwater made

by reinforced concrete caissons) and the new breakwater in the port of Leghorn (rubble mound breakwater topped by a concrete crown wall). These two interventions were developed at the level of Technical and Economic Feasibility Design (PFTE), in the case of the new Genoa breakwater, and at the level of Basic Design and within the starting activities of the Detailed Design for the new breakwater of the Port of Leghorn.

THE NEW BREAKWATER PROTECTING GENOA PORT

The new breakwater was planned to obtain the areas inside the harbour necessary for the safe access of large container ships up to 400 m in length.

The construction typology envisaged for the new breakwater is made of reinforced concrete cellular caissons, up to 28 m wide and 26 m high, placed on a rubble mound base, over sea depths up to 50 m. The caissons are topped by a concrete superstructure and crown wall with a top elevation of 7 m above mean sea level. The rubble mound base is protected on the seaward side by natural rocks up to 5 tons and a toe-protection concrete block.

The new breakwater is subjected to wave conditions characterized by significant wave heights $H_s = 7.0$ m for a 50-year return period and $H_s = 8.5$ m for a 500-year return period. For the evaluation of the wave-induced loads with extreme return periods up to 500 years, a 2D physical model in Froude similarity with 1:50 geometric scale was carried out. An overall plan and a typical section of the works are shown in Figure 1.

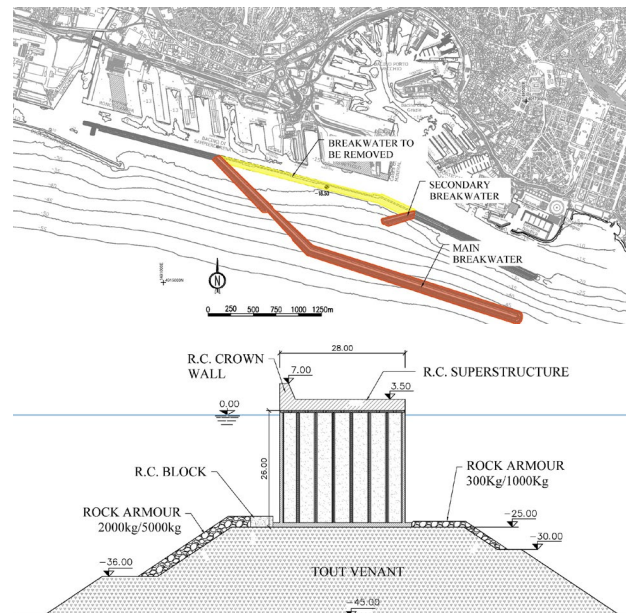


Figure 1 - Genoa vertical composite breakwater

THE NEW BREAKWATER OF LEGHORN PORT

The new breakwater for the Port of Livorno was planned as part of the works of new so called “Europe Platform”, with the aim to expand the harbour areas as necessary to allow the safe access of large container ships.

The construction typology consists of a rubble mound breakwater, interesting sea depths up to - 11.0 m on MSL. The breakwater is made of natural rocks with the seaside armour formed by artificial blocks (accropodes) up to 5 cubic meters, and is topped by a concrete crown wall with a top elevation of + 5.5 m above MSL.

The new breakwater is subjected to extreme waves characterized by $H_s= 4.5$ m for a 50-year return period and $H_s=5.0$ m for a 224-year return period. For the evaluation of the wave-induced loads with extreme return periods up to 224 years, a 2D physical model in Froude similarity with a geometric scale 1:34 was carried out.

The overall interventions plan and a typical breakwater cross section are shown in Figure 2.

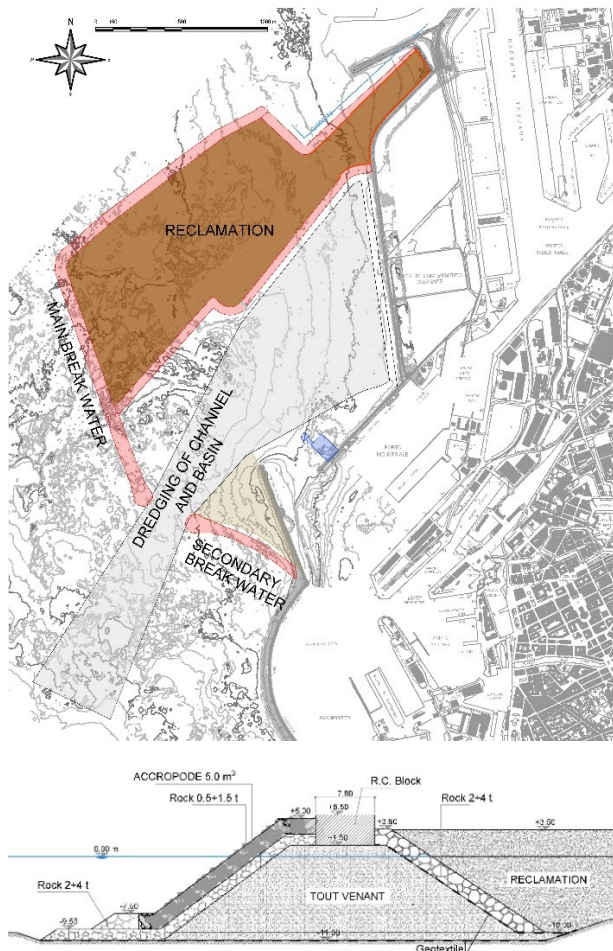


Figure 2 - Livorno rubble mound breakwater

CONCLUSIONS

The lack of a single exhaustive Italian standard addressing in a comprehensive manner also the design of maritime works, leads to uncertainties in the design calculations of coastal and maritime structures.

With reference to gravity type structures like concrete caissons and crown walls, this concerns in particular the stability verifications against sliding and overturning.

One of the most critical aspects is the definition of the return period for assessing the meteomarine design parameters, mainly wave loads, in relation to the application of the NTC 2018 current standards for constructions which do apply the limit state method.

The writers, who participated in the design of the new port breakwaters of Genoa and Leghorn, in the absence of an up-to-date specific guidance for maritime structures, performed the stability verifications with reference to the 1996 Technical Instructions as well as to the NTC 2018. The process allowed to explore the different approaches - and thus different evaluations of the involved meteocanographic loadings - also from a perspective of compromise, with the aim of ensuring the required performances of the works. Upon recommendation of the CSLLPP, the verifications were then developed also with reference to other international standards which specifically encompass maritime works, such as the British Standards (BS).

The verifications carried out will be illustrated in the paper, highlighting how the various regulations lead to different sizing of the works, and the role played in this regard by the different criteria specified for assessing the design meteomarine actions on the structures.

The paper therefore highlights the need for a specific Italian (and probably European) standard for maritime works to enable designers and verifiers, respectively, to carry out and check the design of maritime structures in a clear and consistent approach.

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