Optimization of the Performance of Moored Floating Breakwaters

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ABSTRACT
In this paper a numerical model capable of optimizing the performance of a Moored Floating Breakwater (MFB) through the appropriate modification of the current total unstretched length of the mooring lines, \( L_{unst} \), is developed. The model consists of two modules. The first one includes the identification of the current status of the MFB, which is implemented through the adoption of artificial neural networks. The second one includes the calculation, through successive function evaluations, of the optimum modification of \( L_{unst} \), in terms of satisfying the design target and constraints. The application of the model enables the generation of curves that relate the desired effectiveness of the MFB with a corresponding safety percentage.

KEY WORDS: Moored floating breakwaters; performance; mooring lines; neural networks; optimization.

INTRODUCTION
Moored Floating Breakwaters (MFBs) are nowadays considered as a viable, environmental friendly, alternative solution to conventional bottom-fixed structures that can be effectively used for the protection of coastal and inland water areas with mild up to moderate wave environment conditions. Their dominant design objective, which is related to their operational conditions, is the increase of their effectiveness up to the most possible degree (overall design target). At the same time, however, the satisfaction of this design objective is confined by the strength requirements of the moored floating system, namely the avoidance of any structural failure (overall design constraints). The achievement of the above operational design objective in conjunction with the satisfaction of the corresponding strength design constraints represents the desired, optimum performance of the moored floating system.

The increase of the effectiveness of the most commonly used type of MFBs, which consists of rectangular pontoons moored to the sea bottom with cables or chains, is usually implemented either through the modification of the type, i.e., the geometric and the material characteristics, of the floating pontoon or through the modification of the layout and the characteristics of the mooring lines. For example, dual pontoon MFBs have been proposed by Williams and Abul-Azm (1997) and Bhat (1998), while Malleswara and Madhav (2006) describe the effective performance of perforated floating breakwaters and cage floating breakwaters. Liang et al (2004) introduced the spar buoy floating breakwater, while a floating breakwater made of polyethylene is proposed by Jung et al (2006). On the other hand, the effect of the layout of the mooring lines on the performance of the MFBs is described by Sannassiraj et al (1988). The main characteristic of all the above cases is that the improvement of the performance of the MFB is achieved in a rather “static” way, based on the fact that all these alternatives can only be implemented before the installation of the MFB.

In recent years there is a general trend towards the design of moored floating structures in a manner that enables the improvement of their performance by dynamically modifying their corresponding properties after their installation (Borges de Sousa et al, 1999; Fajinmi and Brown, 1999). This trend has been adopted by Loukogeorgaki and Angelides (2005a, 2005b), who have shown through extensive parametric studies that the improvement of the performance of an installed, single pontoon MFB can be achieved with the appropriate modification of its configuration, which is implemented through the variation of the total unstretched length of its mooring lines, \( L_{unst} \), in a manner that leads to the simultaneous modification of the draft of the MFB. This variation affects straightforwardly the stiffness and the drag damping of the mooring lines and, consequently, it modifies the dynamic response and the effectiveness of the MFB. Moreover, in Loukogeorgaki and Angelides (2005b) a decision framework was also introduced, which demonstrates that for an incident wave of specific frequency, the current total unstretched length of the mooring lines, \( L_{unst} \), can be properly modified in order to result to a value that leads to: (a) the minimization of the wave elevation behind the MFB and (b) the satisfaction of the constraints introduced by the mooring lines. This value is selected among predefined and discrete values of \( L_{unst} \).

The mathematical formulation and the numerical modeling of the above decision framework, which leads to the optimization of the performance of the MFB represents the purpose of the present paper. The numerical model that is developed consists of two modules. The first module includes the identification of the current status of the MFB (expressed with \( L_{unst}^{cur} \)), using the accelerations of its degrees of freedom and the current incident wave frequency, \( \omega_{cur} \). This identification task is implemented through the adoption of artificial neural networks. The output of this module in combination with \( \omega_{cur} \)