ABSTRACT

In this paper, structural optimization is addressed through a density distribution process. The recent increase in information technologies dedicated to optimal design, associated with the progress of the numerical tools, allows significant improvement in the design optimization of mechanical structures. First of all, the geometrical domain of a floating breakwater is discretized into small triangles and each one is represented by the corresponding element in the density vector. Second, the constraints, related to the environmental field of floating breakwaters, have been expressed in terms of this density vector to be expressed later in an optimization problem. Finally, the optimization procedure is developed under the genetic algorithms and satisfactory results are obtained demonstrating the capability of our method.

KEYWORDS: Wave modelling; floating breakwater; optimization; Matlab.

INTRODUCTION

Floating breakwaters present an alternative solution to conventional fixed breakwaters and can be effectively used in coastal areas with mild wave environment conditions. Poor foundation or deep-water conditions as well as environmental requirements, such as phenomena of intense shore erosion, water quality and aesthetic considerations advocate the application of such structures. They have many advantages compared to the fixed ones, e.g. absence of negative environmental impacts, flexibility of future extensions, mobility and relocation ability, lower cost and ability of a short time transportation and installation. As a result of all these positive effects, many types of floating breakwaters have been developed as described by McCartney (1985); however, the most commonly used type of floating breakwaters is the one that consists of rectangular pontoons connected to each other and moored to the sea bottom with cables or chains (Loukogeorgaki and Angelides 2005). Moreover, many studies have been produced on floating breakwaters (Johansson 1989; Murali and Mani, 1997; etc.), mainly concerning the wave protection improvement by different types of floating structures. Other studies have been directed towards the mooring forces and motion responses to understand the behaviour of the floating breakwaters due to sea waves (Williams and Abul-Azm,1997; Sannasiraj, 1999; and Lee 2003). Yet non of these studies have been discussing the structural design of floating breakwaters or more even optimizing its form, ignoring an essential evident, that a moored floating breakwater should be properly designed in order to ensure effective reduction of the transmitted energy and, therefore, adequate protection of the area behind it.

In fact, optimization of breakwaters has been previously discussed by Ryu and Park (2005) and focused on minimizing the cost function imposed to structural failure constraints, and also by Castillo and Munguez (2006) for composite breakwater types and similarly concerning the minimization of initial/construction costs subjected to yearly failure rate bounds for failure modes; where in this paper, the study is directed towards optimization of floating breakwaters to reduce its weight, or to represent a new form, in accordance to the physical and mechanical constraints using a density distribution vector. But it is good to declare that there is some work spent on shape optimization in ocean field but for offshore structures only; for example Chou (1977) derived optimal shapes for a buoy and an ocean platform supported by four columns proposing an analytical procedure, Akagi & Ito (1984) optimized the heave motion of a hydrodynamic transparent semi submersible using a quadratic programming technique, Kagemoto (1992) optimized the arrangement of vertical floating cylinders in waves, Clauss & Birk (1996) focused on hydrodynamic shape optimization for large offshore structures (oil platforms) based on non linear programming algorithms.

The optimization and mainly the topology optimization generates the optimal shape of a mechanical structure by representing a new mass distribution; it is interesting to briefly review some related works in this field to evaluate our proposed method among the others applied in this domain. It is mainly based on two approaches: An approach introduced by Bendsoe and Kikushi (1988) is that of homogenization, it consists in dealing with a continuous density of material. In the end of this deterministic optimization, the current density is forced toward value 1 or 0, that respectively stands for material presence or absence and it is limited only to the linear elasticity case. Moreover, it cannot address loading that apply on the actual boundary of the shape to be determined and hardly handles optimization for multiple loadings. Another approach to topology design is that of stochastic optimization, such as involved in simulated annealing and genetic algorithms. The GA methods have been applied to topological optimization by Jensen (1992), Chapman (1994) and Kane (1995); but what attracted us is optimization based on GA due to its powerful strength in dealing with problems with large number of variables as the case of topology optimization. They have gradually been recognized as powerful stochastic optimization algorithms far away since the seminal work of Holland (1975) and the comprehensive study of Goldberg. Their strength proceeds from their wide range of applications: GA can handle non derivable, non continuous and even non analytically defined functions. For these reasons they can be used in problems for which there are no data on the possible solution; hence they are useful in some irregular or special kinds of problems including ours.