

## **3D BEM-FEM Hybrid Hydroelastic Analysis of Module Linked Large Floating Structures Subjected to Regular Waves**

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### **ABSTRACT**

This study is concerned with a three-dimensional BEM-FEM hybrid hydroelastic analysis of module linked large floating structures subjected to regular waves. Modules and connectors of the floating structures are discretized by finite elements using eight-node isoparametric elements. Mindlin's plate theory is used to take into account flexural as well as shear deformation of the structures. The fluid structure interface is discretized by boundary elements using eight-node quadratic elements. Equation of motion of the structures coupled with fluid is constructed by combining boundary and finite elements at the interface nodes. Numerical examples are presented to show the accuracy and efficiency of the present method by comparing with previous theoretical and experimental results for wet mode free vibration and regular wave response. The effect of connector flexibility on the response is also discussed.

**KEYWORDS:** module linked large floating structure, BEM-FEM hybrid model, wet mode free vibration, regular wave response, connector flexibility, hydroelasticity, quadratic boundary element

### **INTRODUCTION**

Large floating structures such as floating airports and cities will be constructed by connecting multiple modules with connectors. The dynamic behavior of such structures is considerably different from that of mat-like uniform structures which can be usually investigated by a continuum approach on the basis of beam theory (Inoue *et al.*, 1997; Aoki, 1997) and plate theory (Hamamoto, 1995; Kashiwagi and Furukawa, 1997).

Numerical methods such as FEM and BEM are suitable to deal with the hydroelastic problem of large floating structures with arbitrary shapes as well as

nonuniform connector arrangement. A number of studies on the hydroelastic analysis of large floating structures have been carried out by numerical methods in recent years. Riggs and Ertekin (1993) have performed the dynamic analysis of semisubmersible module linked floating structures by FEM and strip theory. Hamamoto and Fujita (1995) have studied the dynamic behavior of module linked large floating structures by a BEM-FEM hybrid method. Takaki and Gu (1997) and Ma and Hirayama (1997) have studied wave induced motion of large floating structures by coupling FEM and source distribution method.

In this study, the hydroelastic analysis of module linked large floating structures subjected to regular waves is carried out by a newly developed three dimensional BEM-FEM hybrid method. Each module and connector are discretized by finite elements using eight-node isoparametric elements. Mindlin's plate theory is used to take into account flexural and shear deformation of relatively thick modules and connectors. On the other hand, the fluid domain is discretized by boundary elements. Only the fluid structure interface is discretized by eight-node quadratic boundary elements because the Green function to be used in this study satisfies a three dimensional Laplace equation, free surface condition, seabed condition and Sommerfeld's radiation condition. The equation of motion of module linked large floating structures is constructed by coupling BEM and FEM, taking account of the compatibility condition between boundary and finite elements on the fluid structure interface. Undamped wet mode free vibration analysis is carried out by an iterative method since the added mass is frequency dependent. Then, the wave response analysis is performed for incoming regular waves on the basis of a wet mode superposition approach.

Numerical examples are presented to show the accuracy and efficiency of the BEM-FEM hybrid hydroelastic analysis using quadratic boundary elements.