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Minimizing differential deflection in a pontoon-type, very large floating structure via gill cells

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Abstract

When a pontoon-type, very large floating structure is heavily loaded in the central portion, it will deform with its central deflection much larger than its corner deflections. The resulting differential deflection, if large enough, may cause machines and equipment sensitive to differential deflection to cease operation or the floating structure to be subjected to additional large stresses. In this paper, we introduce the so-called gill cells which are compartments within the floating structure with holes or slits at the bottom floor to allow water to flow in and out freely. It will be shown herein that these gill cells reduce the differential deflection and the bending stresses significantly while maintaining the structural stiffness integrity by using the example problem of a super-large floating container terminal.
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Keywords: Very large floating structures; Mitigating differential deflection; Gill cells; Container terminals; Static analysis

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1. Introduction

There are basically two types of very large floating structures (VLFSs), namely the semi-submersible-type and the pontoon-type [1,2]. Semi-submersible-type floating structures are raised above the sea level using column tubes or ballast structural elements in order to minimize the effects of waves while maintaining a constant buoyancy force. Thus, they can reduce the wave-induced motions and are, therefore, suitably deployed in high seas with large waves. In contrast, pontoon-type floating structures lie on the sea level like a giant plate floating on water. These pontoon-type floating structures are suitable for application in calm waters, often inside a cove or a lagoon and near the shoreline. VLFSs have been termed as Mega-Floats by the Japanese engineers. Suzuki [3] defined VLFS not only as floating structures with large length dimensions but also having lengths larger than the characteristic length that depends on the ratio of structural stiffness and buoyant-spring stiffness. Owing to these structural dimensions, an elastic response in the VLFSs is more dominant than their rigid-body motions. In this paper, we focus on the pontoon-type VLFS.

Referring to Fig. 1, a Mega-Float system consists of (a) a very large pontoon-type floating structure, (b) station keeping system to keep the floating structure in place, (c) an access bridge or a floating road to get to the floating structure from shore, and (d) a breakwater (usually needed in high seas) for reducing wave forces impacting the floating structure.

These pontoon-type VLFSs or Mega-Floats have advantages over the traditional land reclamation solution for birthing land from the sea in the following respects:

- they are cost effective when the water depth is large and the seabed is soft,
- environmental friendly as they do not damage the marine eco-system, or silt-up deep harbours or disrupt the tidal/ocean currents,
- they are easy and fast to construct (components may be made at different shipyards and then brought to the site for assembling),
- they can be easily removed (if the sea space is needed in future) or expanded (since they are of a modular form),
- the facilities and structures on Mega-Floats are protected from seismic shocks since they are inherently base isolated,
- they do not suffer from differential settlement due to reclaimed soil consolidation,

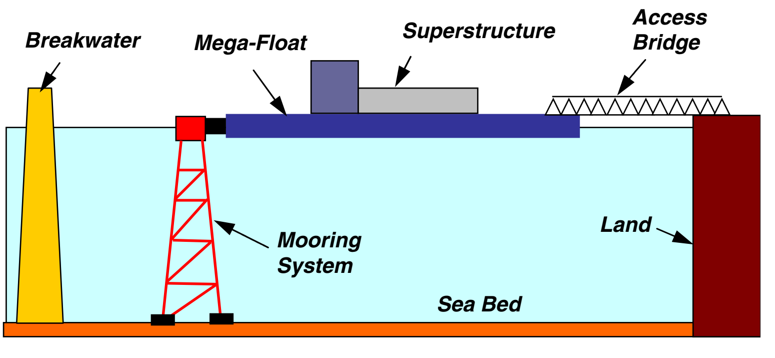

Fig. 1. Components of a pontoon-type VLFS or Mega-Float.

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