

Coupled response of compliant offshore platforms

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A three-dimensional finite element analysis has been used to simulate the coupled static and dynamic behaviour of compliant ocean structures. Nonlinearities which result from large deflections, reduced or zero stiffness in compression, and nonconservative fluid loading are considered. The spatial variation of fluid loading is also addressed. The structures are assumed to be in the Morison regime. Linear wave theory is used and multidirectional seas may be simulated. A variable current profile may be specified and concentrated masses and loads, as well as foundation properties, may be modelled. Updated Lagrangian coordinates and a residual feedback, incremental-iterative, solution is adopted. Viscous relaxation is used to start the static solution of problems with small initial stiffnesses. The dynamic solution is performed in the time domain and uses the Newmark integration scheme. Consistent mass matrices are developed for both beam-column and cable elements. The directionality of the hydrodynamic added mass is accounted for, as is the discontinuity of the mass density for elements which pierce the water surface. Examples are presented of an articulated tower, of a guyed tower, and of a tension leg platform.

Key words: offshore construction works, static response, dynamic response

The economic production of petroleum in deep water requires structures which often test the limits of existing technology. Compliant production platforms are one such class of deep water structures. Since they are compliant, these structures must be designed dynamically. Also, since they are exposed to loads which vary in a nonlinear way and are themselves mechanisms which behave in a nonlinear manner, their analysis is highly complex. In this study a finite element model is developed which deals with nonlinear dynamic problems of compliant platforms.

A compliant ocean structure is one which moves significant lateral distances when subject to wave and wind loadings. It relies upon its dynamic softness to reduce maximum transmitted anchorage loads. Unlike the fixed structure where structural velocities and accelerations are small and the time-varying wind and wave loads may be treated as a time series of static problems, the compliant structure has significant kinematics and the role of structural mass, added mass, and damping must be considered.

Compliant tower concepts

Compliant structure concepts may be classified in one of four categories:

- Articulated towers
- Guyed towers
- Tension-leg platforms
- Floating production facilities

The concepts differ mainly in the means by which the loadings are transmitted to the seabed and in the form of the anchorage to the sea floor. They all resemble inverted pendulums, with excess buoyancy replacing gravity loads.

The articulated tower consists of a vertical column to which buoyancy has been attached near the water surface and to which ballast is usually added near the bottom. The tower is connected to the sea floor through an articulated hinge joint to a base which may be of either piled or gravity-type. The tower itself may be either a tubular