ABSTRACT

Free and forced vibration analysis of submarine pipelines and fixed offshore framed structures subjected to dynamic wave forces is investigated using the finite element method. Wave forces are obtained by Morison equation in which the water particle velocities and accelerations are obtained by Airy linear wave theory.

The present study mainly consists of three parts; out-of-plane analysis of submarine pipelines, two-dimensional analysis and three-dimensional analysis of submarine pipelines and fixed offshore framed structures.

In the out-of-plane analysis of submarine pipelines the initial deflections (in their plane) are obtained from the nonlinear large-angle bending problem. Then small-angle dynamic responses are assumed in the normal-to-plane direction. While for two- and three- dimensional problems the dynamic analysis is accomplished under the assumption of small displacements around the static configuration without any nonlinearities.

The effect of the surrounding fluid added mass is studied for free and forced vibrations where both lumped and consistent mass formulations are used. The nodal wave forces are obtained by the lumped-force technique in which the force vector has no moment components. The effects of member inclination on Morison equation and the effects of partially submerged members on nodal forces are investigated.

In three-dimensional problems the wave forces are obtained by generalizing the one-dimensional Morison equation. Also the water particle kinematics are obtained by generalizing the one-dimensional Airy linear wave theory in which the effect of wave direction on structural behavior is investigated.

Three computer programs are built for the two-dimensional, three-dimensional and out-of-plane problems. In these programs the natural frequencies and mode shapes are obtained by Jacobi method and the dynamic responses are carried out by mode superposition technique. The results of the programs are checked against NASTRAN computer program and the agreement is very good.

The number of modes that must be considered in modal analysis is well investigated. Also in the present study the structural damping effect and the effect of drag and inertia components of wave forces on dynamic responses are presented.

The results showed that the added mass reduced the dynamic responses to about 75% in the case of submarine pipelines but its effect is negligible in the case of offshore towers, which reduced responses only 10%. Damping has slight effect on the dynamic responses and it reduced these responses to about 19%. The change in wave direction from 0˚ to 90˚ increased the responses corresponding to in-plane displacement to about 21% but it has larger effect on responses corresponding to out-of-plane displacements which increased to about 60%.