THE WIND INDUCED VIBRATION AND FATIGUE OF FLOATING ROOFS ON OIL STORAGE TANKS

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Abstract

The subject of this dissertation is the motion under the wind of floating roofs in oil tanks, and the associated stresses and fatigue damage.

A simplified model of a single deck floating roof is described, comprising a thin rectangular plate floating on a finite body of incompressible liquid. Governing equations are derived and a harmonic analysis applied. Normal modes of the system are found, and the transfer function at the plate surface is obtained as a modal sum. Large amplitude and high frequency effects are also considered. A spectral analysis is performed to determine statistics of the displacement response to a wind induced pressure loading at the surface.

An experimental investigation into behaviour under harmonic and point random loads is described and compared with theory. Agreement between theory and experiment is strong at low frequencies where liquid effects dominate and at high frequencies where boundary reflections are small. Results from wind tunnel tests are also compares with theory. Properties of displacement response are found to be accurately predicted. Stress analyses are given. Spectral analysis techniques are employed to generate bending stress statistics. Statistics of membrane stresses are inferred from displacement statistics.

Fatigue life expectancy estimates are generated are generated in a simulation using data from real tanks. Membrane stresses are found to be the chief mechanism from damage. Calculated life expectancies are high, ranging from 25 years to infinity. The dependence of life expectancy on wind speed, weld quality, damping, roof thickness and tank diameter are discussed.