Background: During the 2003 Tokachi-oki earthquake, Japan, many oil-storage tanks of floating roof type located at Tomakomai area were seriously damaged. Damages are supposed to be caused by sloshing.

Objectives: To propose a response spectrum method to predict the sloshing response of a floating roof in a cylindrical liquid storage tank under seismic excitation.

Outline of analysis: (1) Derivation of analytical or numerical solution to the boundary-value problem for the coupled liquid-floating roof system, (2) Derivation of the diagonalised equations of motion based on expanding the response of the floating roof into the free-vibration modes in liquid, and (3) Modal analysis based on the response spectrum.

Basic assumptions: (1) The liquid is inviscid, incompressible and irrotational.  (2) The tank wall is rigid. (3) The floating roof is idealized as an orthotropic elastic plate with arbitrary axisymmetric form. (4) The floating roof is always in contact with the liquid surface. (5) The wave elevation as well as the vertical displacement of the floating roof is so small that linear superposition principle may be assumed to be valid. (6) The tank is subjected to a horizontal ground motion in one direction.

Analysis and results: Tank model: Oil-storage tank with a single-deck type floating roof

Input ground motion: 2003 Tokachi-oki earthquake recorded at Tomakomai K-NET station (EW)

Tank sizes: • Radius \( R = 40 \text{m} \)  
• Liquid height \( H = 20 \text{m} \)

Conclusions: (1) A response spectrum method has been proposed to predict the sloshing response of a floating roof in a cylindrical liquid storage tank under seismic excitation. (2) The validity of the proposed method has been confirmed by comparison with the results of time history analysis. (3) It can be concluded that the CQC method is preferable than the SRSS method because the former gives better predictions for both the roof displacement and the bending stresses, which are close to the results of time history analysis.