EFFECTS OF FOUNDATION SETTLEMENT ON OIL STORAGE TANKS

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Abstract

Differential vertical settlement around the circumference of the foundation of large open-topped oil storage tanks can produce deformation of the tank shell including radial deflection of the tank shell. These tanks usually incorporate a floating roof which rests on the surface of the oil and thus moves vertically as the oil level changes. A flexible seal is provided between the edges of the roof and the tank shell to restrict evaporation losses. Excessive radial deflections in the malfunction of the seal and jamming of the floating roof.

The results of an analysis by Malik *et.al*, based on the assumption that the behaviour of the shell is inextensional are outlined. Two further analyses of the tank and the primary wind girder are presented. Both of these are simple, but use less restrictive assumptions that the inextensional analysis. In the first, the shell is considered to act as a membrane. The second analysis makes use of a simplified version of the modified version of the modified Donnell equation. The results of these analyses are compared with those of the analysis based on the extensional behaviour of the shell. The limits of validity of the three different analyses are identified. It is proposed that the membrane solution is valid for all practical applications, and the results are presented in non-dimensional form. It is shown that the membrane analysis can be used to predict a suitable jacking profile for any tank foundation in need of relevelling.

Application of the membrane analysis to localised settlement profiles commonly found in practice, and comparison with the solutions of the extensional analysis demonstrates the inaccuracy of the inextensional solution for local settlement profiles which subtend an angle

$\alpha \approx 100^0$ or less at the centre of the tank. The results of the membrane analysis are presented in easy to use non-dimensional plots.

The results of small scale model testing carried out on a 1:50 empty model tank made from *Melinex* agree favourably with the predictions of the membrane analysis for deflections. Tests with the tank full of water show significant increase in the bending stiffness of the shell due to a tensile stress set up in the tank. This will lead to conservative predictions of shell displacements.

An approximate method for prediction of the settlement conditions which cause the tank to *bridge* is presented. Investigation into the phenomenon of bridging which causes the edge of the tank to lose contact with the foundation was carried out. The experimental observations for the amplitudes of settlement at the onset of bridging show initiation of bridging at very small amplitudes of settlement for short wavelength settlement profiles.

The agreement for the strain results are not as good however, the discrepancies are partly attributed to *short wave* effects not incorporated in the theoretical model.