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Experimental Investigation to Local Settlement of Steel Cylindrical Tanks with Variable and Constant Thickness

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ABSTRACT

Nowadays the use of thin-walled structures is widely accepted. The main reason for this is low weight and high resistance of these structures. In order to reduce the weight and cost of the structure, cylindrical steel tanks can be made in variable thickness. In general, foundation's settlement occur beneath the reservoir walls due to specific soil properties, which are divided into three general components: 1- Uniform Settlement 2- Tilt Settlement 3- Local Settlement. Among these components, Local settlement has the greatest impact on the reservoir shell. However, its value is the lowest among the three. This component can cause large radial displacements, shell buckling and even tank failure. In this research, three steel cylindrical tanks, two specimens of constant thickness and one specimen of variable thickness in height, are first modeled in finite element software and then made in the laboratory and subjected to local settlement at the edge of their floor. And the values of settlement, buckling load, final load, stress and radial deformation is compared. The data obtained from the eigenvalue analysis show that the effect of increasing the thickness on the critical buckling load is extremely high and the higher thickness at the lower part of the shell is highly influential. The results of Nonlinear analysis indicate that the behavior of tank with variable thickness is acceptable compared to other samples. Comparison of the results between numerical and experimental modeling also indicate good agreement between these two methods.

Keywords: Experimental Investigation, Variable Thickness, Cylindrical Tanks, Finite Element Software, Local settlement, Radial Displacement

1. Introduction

From a geometrical point of view, steel tanks have a very low thickness compared to the other two dimensions and thus are classified as thin-walled structures and their associated conditions. The use of thin-walled structures is now widely accepted. The main reason for this is the low weight and high resistance of these structures. However, the imperfections in these structures are inevitable which, along with the boundary conditions, affect the behavior of these structures and their buckling capacity.

In order to provide the appropriate weight of a structure in large tanks reinforced by circular rings, these structures often act as carriers for the loads themselves. These structures should be resistant to incoming loads such as liquid load inside the tank, gravity load of the structure and side loads such as wind and earthquake. Theoretical equations for cylindrical shells with constant thickness were first presented by von Mises (1929), Windenburg and Trilling (1934) and von Sanden and Gunther (1952). These equations are now also used for convenience and proper solutions. [1]

2. Background

In order to optimize the use of materials, weight and cost of the structure, cylindrical steel tanks can be made in variable thickness. Research in this area is scant and further studies are needed. Effects of Different Thicknesses of the Reservoir Wall on its Behavior under Harmonic settlement was examined by Ahmed Shamel Fahmy and Amr Mohamed Khalil by Sap2000 software. The purpose of their study was to determine the effects of different thicknesses of the reservoir wall on its behavior under critical harmonics settlement. The study was carried out on 4 tanks with the same geometry and materials and different thicknesses. The results show that tanks with similar thickness exhibit similar buckling mode behavior and as the wall thickness increases, this mode begins to change. The research also stated that in the case of analysis for tanks regardless of the thickness variations, the wall thickness values should be the average obtained from the design equations. [3]

3. The cases examined in this study

In this study, 3 laboratory-scale cylindrical steel tanks were constructed in the Structural Laboratory of Urmia University and were subjected to local settlement on their lower edge. Table 1 indicates the thicknesses of the samples.

Table 1: Thickness of Samples

	S1	S2	S3
Bottom Thickness	0.3mm	0.6mm	0.6mm
Middle Thickness	0.3mm	0.6mm	0.5mm
Upper Thickness	0.3mm	0.6mm	0.3mm
Reinforcement Ring Thickness	3mm	3mm	3mm

It should be noted that the diameter of the cylindrical tank is 1000 mm and its height is 240 mm, which is divided into three part of 80 mm parts in the sample with variable thickness. The ring dimensions used in these specimens are L 30 * 30 mm.