# THE EFFECT OF LONG-TERM CORROSION ON DYNAMIC BEHAVIOUR OF UNANCHORED STEEL CYLINDRICAL TANKS

Marzie ZARIFKAR
*Department of Civil Engineering, Shiraz, Iran*
*marzie.zarifkar@gmail.com*

Mahmoud R. MAHERI
*Professor, Shiraz University, Shiraz, Iran*
*maheri@shirazu.ac.ir*

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## ABSTRACT

In this paper, long-term corrosion effects on dynamic characteristics of unanchored steel cylindrical tanks are investigated. The corrosion effect is considered as thinning of the upper and lower parts of the wall over time. Dynamic analyses are performed on three different models with different wall thicknesses and height to diameter ratios of 0.4, 0.63 and 0.95 using ANSYS finite element software. In the analyses, the tank's liquid is considered to be crude oil with a level at 90% of the height of the tank. The tank's base is unanchored and without any constraint and is in contact with the foundation through the effect of its weight. For determining the tank dynamic characteristics, including natural frequencies and the corresponding mode shapes, the models are analyzed using linear modal analysis. Comparing the natural frequencies of the corroding unanchored tanks with those of the non-corroded tanks reveals reduction in the stiffness of the tanks due to thinning effects of corrosion. The results of investigations also indicate substantial influence of long-term corrosion on the mode shapes of the tank. As the tank ages, its mode shapes change to completely different forms. Also, comparing the results of numerical natural frequencies with those of the code-recommended approximate methods shows that the latter approximate solution for natural frequencies presents reasonable results for the short tank (H/D = 0.4). However it errs considerably as the height of the tank is increased.

## INTRODUCTION

Land-based vertical cylindrical tanks are one of the most prominent industrial structures used widely in oil and petroleum industries for storing different fluids. Most of the structure of these tanks is located on the ground and usually their bases are directly on concrete foundations or consolidated soils. In unanchored tanks, there is no mechanical connection between the tank and the foundation, and the earthquake-induced base shear of the tank is resisted only by the friction between the tank's base and the foundation.

Steel corrosion is one of the reasons for tank's failure during the utilization of the structure. The tank's service life is generally between 20 to 40 years and in some cases the corrosion phenomenon is detected after 1.5 to 2.5 years (Medvedeva and Tiam, 1998). The American Petroleum Institute states that; approximately 20% of hydrocarbon products lost as leakage are caused by corrosion damage in storage tanks (API Standard 650, 1988). Corroded steel tanks are particularly susceptible to seismic loading as the imperfections caused by corrosion highly amplify the seismic response. Corrosion in steel storage tanks occurs mainly due to the presence of well water, water condensate, atmospheric oxygen and acid gases inside the tank. The atmospheric corrosion of the tank from outside is reported to be less significant (Zagórski et al., 2004). Oil-derivative sediments containing, among others, hydrogen sulfide add to the local acidification of the environment. As a result of the above factors, the sections of the shell most susceptible to corrosion are the lower and the upper parts of the tank wall. Therefore, regarding the state of corrosion, the wall of the tank