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

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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 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. The long-term effect of corrosion is a significant thinning of the wall section, particularly at lower levels; resulting in imperfections in the shell.

Little is reported on the effects of corrosion on the dynamic and seismic response of steel storage tanks. In a recent work, Dehghan-Manshadi and Maheri (2010) investigated the effects of imperfections due to long term corrosion on the linear dynamic characteristics of anchored steel cylindrical storage tanks. Maheri and Abdollahi (2013) furthered that work by investigating the nonlinear buckling response of anchored steel tanks subjected to earthquake loading.

In the proposed paper, the work carried out in Dehghan-Manshadi and Maheri (2010) is furthered by investigating the long-term corrosion effects on dynamic characteristics of 'unanchored' steel cylindrical tanks. The corrosion effect is considered as thinning 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. ANSYS finite element software is used for these analyses. 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 corresponding mode shapes, the models are analyzed using modal analysis. The objective of this analysis is to determine the long-term corrosion effect on natural frequencies and their corresponding mode shapes.

Comparing the fundamental natural frequency of the unanchored tanks with that of its equivalent anchored tanks as they degrade by corrosion (Table 1) shows that the unanchored tank is more flexible than the anchored tank and the long term corrosion also reduces the stiffness of the tank. Also, comparing the results of numerical analyses with the approximate method presented by Veletsos (1974) 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. The results of investigations also indicate substantial influence of long-term corrosion on the mode shapes of the tank as can be seen in Figure 1 for a typical mode of the tall tank. As the tank ages, its mode shapes change to completely different forms. Other dynamic properties of the unanchored steel land-based cylindrical tanks are also greatly affected by corrosion.

Table 1. Comparison of natural frequencies of the unanchored and anchored tank with aspect ratio of 0.63 (m=1, n=1)

Aging (years)	m	n	Anchored	Unanchored
			Frequency (Hz)	Frequency (Hz)
0	1	1	5.532	4.422
5	1	1	5.316	4.167
10	1	1	5.081	3.861
15	1	1	4.799	3.484
20	1	1	4.409	3.003
25	1	1	3.868	2.358

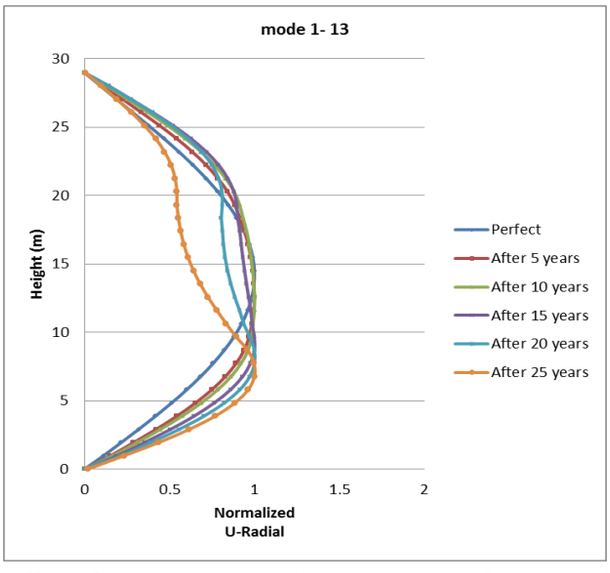

Figure 1. The effect of corrosion on a typical mode shape of the tall tank (H/D=0.95)

REFERENCES

Dehghan-Manshadi SH and Maheri MR (2010) The effects of long term corrosion on the dynamic characteristics of ground based cylindrical liquid storage tanks, *Thin-Walled Structures*, 48(12): 888-896

Maheri MR and Abdollahi A (2013) The effects of long-term corrosion on the buckling of ground based steel tanks under seismic loading, *Thin-Walled Structures*, 62: 1-9

Veletsos AS (1974) Seismic effects in flexible liquid storage tanks, In: *Proceedings of the Fifth World Conference on Earthquake Engineering*, 1: 630–639