BUCKLING RESPONSE OF CORRODING GROUND BASED STEEL STORAGE TANKS UNDER SEISMIC LOADING

Armin ABDOLLAHI
Department of Civil Engineering, Shiraz, Iran
armin_abdollahi@yahoo.com

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

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Material degradation due to corrosion significantly alters the seismic response of ground-based cylindrical steel storage tanks. Steel liquid storage tanks are highly susceptible to corrosion from within. The long-term effect of corrosion is a significant thinning of the wall section, particularly at lower levels; resulting in imperfections in the shell. Investigations on the effects of imperfections in thin cylindrical shells show that; large local buckling can occur at the locations of the imperfections. 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 in 2010 investigated the effects of imperfections due to long term corrosion on the linear dynamic characteristics of steel cylindrical storage tanks. They found that progressive corrosion has significant effects on the tank fundamental period and its associated mode shape of vibration, as well as, the magnitude and location of the maximum hydrodynamic pressures exerted on the tank. The present work draws from the work reported in reference (Virella et al., 2006) and furthers the recent work by Dehghan-Manshadi and Maheri by investigating the effects of long-term corrosion on the buckling response of liquid storage tanks subjected to horizontal ground excitation. The three tank models considered in both references are utilized to investigate the effects of age-dependent uniform thinning of tank shell due to corrosion on the buckling response of the tanks subjected to the same earthquake records.

In the proposed paper, a numerical study is conducted to investigate the effects of internal shell corrosion on the dynamic buckling of three cone roof ground-based, steel cylindrical tanks with height to diameter ratios (H/D) of 0.40, 0.63 and 0.95, subjected to horizontal seismic base excitations. Internal corrosion is considered as a time dependent uniform thinning of the wall at the upper and the lower parts of the tank being in contact with, respectively, atmospheric oxygen and acid gases and residual water. Detailed numerical models of the tank-liquid systems at different stages of corrosion degradation are subjected to two representing accelerograms and for each model the critical peak ground acceleration (PGA) for dynamic buckling of the shell and its associated mode of failure are evaluated. The critical PGA and the buckling mode of different tank models are given in Table 1. Typical pseudo equilibrium paths for the critical node of the tank model C subjected to the El Salvador accelerogram are also shown in Figure 1.

It is found that in all three tanks, the critical PGA is markedly reduced with thinning of the shell, irrespective of the type of ground input. The buckling mode of failure of the tanks also changed from an elastic diamond-shaped failure at the top of the shell to an elasto-plastic elephant foot type failure near the base, after 10 years for the shorter tanks (H/D = 0.4 and 0.63) and after 15 years for the tallest tank. The effects of uniform corrosion degradation on the critical buckling load of the tanks was found to be such that after 20 years of thinning due to corrosion, the static loading alone was responsible for the elephant foot buckling of the shell.

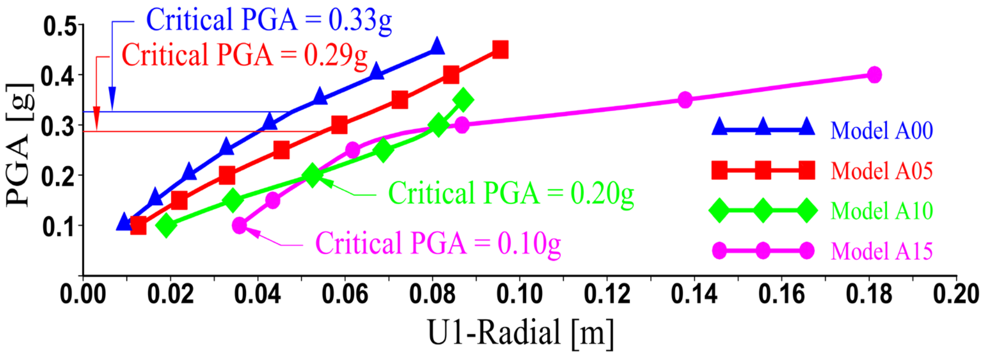

Figure 1. The pseudo equilibrium paths for the critical node of the tank model C subjected to the El Salvador accelerogram

Table 1. The critical PGA and the buckling mode of different tank models

Model	**Age (years)**	**H/D**	**Earthquake Accelerogram**					
			Parkfield			**El Salvador**		
			Critical PGA (g)	**Buckling Mode**	**Type of Buckling**	**Critical PGA (g)**	**Buckling Mode**	**Type of Buckling**
A00	0	0.4	0.25	Diamond	Elastic	0.277	Diamond	Elastic
A05	5		0.22	Diamond	Elastic	0.21	Diamond	Elastic
A10	10		0.10	EF	Plastic	0.10	EF	Plastic
A15	15		-	EF (Static)	Plastic	-	EF (Static)	Plastic
B00	0	0.63	0.23	Diamond	Elastic	0.26	Diamond	Elastic
B05	5		0.21	Diamond	Elastic	0.20	Diamond	Elastic
B10	10		0.15	Diamond	Elastic	0.19	Diamond	Elastic
B15	15		0.10	EF	Plastic	0.10	EF	Plastic
B20	20		-	EF	Plastic	-	EF	Plastic
C00	0	0.95	0.25	Diamond	Plastic	0.33	Diamond	Elastic
C05	5		0.245	Diamond	Plastic	0.29	Diamond	Elastic
C10	10		0.15	Diamond	Elastic	0.20	Diamond	Elastic
C15	15		0.10	Diamond	Elastic	0.10	EF	Plastic
C20	20		-	EF	Plastic	-	EF	Plastic
C25	25		-	EF (Static)	Plastic	-	EF (Static)	Plastic

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