M_{rw} = the overturning moment applied at the bottom of the shell due to the seismic design loads in foot-pounds (N-m) (also known as the "ringwall moment")
D = tank diameter in feet
W_s = total weight of tank shell in pounds

15.7.5 Anchorage

Tanks and vessels at grade are permitted to be designed without anchorage where they meet the requirements for unanchored tanks in reference documents. Tanks and vessels supported above grade on structural towers or building structures shall be anchored to the supporting structure.

The following special detailing requirements shall apply to steel tank and vessel anchor bolts in SDC C, D, E, and F. Anchorage shall be in accordance with Section 15.4.9, whereby the anchor embedment into the concrete shall be designed to develop the steel strength of the anchor in tension. The steel strength of the anchor in tension shall be determined in accordance with ACI 318, Appendix D, Eq. D-3. The anchor shall have a minimum gauge length of eight diameters. Post-installed anchors are permitted to be used in accordance with Section 15.4.9.3 provided the anchor embedment into the concrete is designed to develop the steel strength of the anchor in tension. In either case, the load combinations with overstrength of Section 12.4.3 are not to be used to size the anchor bolts for tanks and horizontal and vertical vessels.

15.7.6 Ground-Supported Storage Tanks for Liquids

15.7.6.1 General

Ground-supported, flat bottom tanks storing liquids shall be designed to resist the seismic forces calculated using one of the following procedures:

a. The base shear and overturning moment calculated as if the tank and the entire contents are a rigid mass system per Section 15.4.2 of this standard.
b. Tanks or vessels storing liquids in Risk Category IV, or with a diameter greater than 20 ft (6.1 m), shall be designed to consider the hydrodynamic pressures of the liquid in determining the equivalent lateral forces and lateral force distribution per the applicable reference documents listed in Chapter 23 and the requirements of Section 15.7 of this standard.
c. The force and displacement requirements of Section 15.4 of this standard.

The design of tanks storing liquids shall consider the impulsive and convective (sloshing) effects and their consequences on the tank, foundation, and attached elements. The impulsive component corresponds to the high-frequency amplified response to the lateral ground motion of the tank roof, the shell, and the portion of the contents that moves in unison with the shell. The convective component corresponds to the low-frequency amplified response of the contents in the fundamental sloshing mode. Damping for the convective component shall be 0.5 percent for the sloshing liquid unless otherwise defined by the reference document. The following definitions shall apply:

D_i = inside diameter of tank or vessel
H_L = design liquid height inside the tank or vessel
L = inside length of a rectangular tank, parallel to the direction of the earthquake force being investigated
N_h = hydrodynamic hoop force per unit height in the wall of a cylindrical tank or vessel
T_c = natural period of the first (convective) mode of sloshing
T_i = fundamental period of the tank structure and impulsive component of the content
V_i = base shear due to impulsive component from weight of tank and contents
V_c = base shear due to the convective component of the effective sloshing mass
y = distance from base of the tank to level being investigated
γ_L = unit weight of stored liquid

The seismic base shear is the combination of the impulsive and convective components:

$$V = V_i + V_c \tag{15.7-4}$$

where

$$V_i = \frac{S_{ai} W_i}{\left(\frac{R}{I_e}\right)} \tag{15.7-5}$$

$$V_c = \frac{S_{ac} I_e}{1.5} W_c \tag{15.7-6}$$

S_{ai} = the spectral acceleration as a multiplier of gravity including the site impulsive components at period T_i and 5 percent damping

For $T_i \le T_s$

$$S_{ai} = S_{DS} \tag{15.7-7}$$

For $T_s < T_i \le T_L$

$$S_{ai} = \frac{S_{D1}}{T_i} \tag{15.7-8}$$