the sum of the squares (SRSS) method where the modal periods are separated. If significant modal coupling may occur, the complete quadratic combination (CQC) method shall be used.

c. Vertical earthquake forces shall be considered in accordance with the applicable reference document. If the reference document permits the user the option of including or excluding the vertical earthquake force to comply with this standard, it shall be included. For tanks and vessels not covered by a reference document, the forces due to the vertical acceleration shall be defined as follows:
   (1) Hydrodynamic vertical and lateral forces in tank walls: The increase in hydrostatic pressures due to the vertical excitation of the contained liquid shall correspond to an effective increase in unit weight, γ_L, of the stored liquid equal to $0.2S_{DS}\,\gamma_L$.
   (2) Hydrodynamic hoop forces in cylindrical tank walls: In a cylindrical tank wall, the hoop force per unit height, N_h, at height y from the base, associated with the vertical excitation of the contained liquid, shall be computed in accordance with Eq. 15.7-1.

$$N_h = 0.2S_{DS}\gamma_L\,(H_L - y)\left(\frac{D_i}{2}\right) \qquad (15.7\text{-}1)$$

where

D_i = inside tank diameter
H_L = liquid height inside the tank
y = distance from base of the tank to height being investigated
γ_L = unit weight of stored liquid

   (3) Vertical inertia forces in cylindrical and rectangular tank walls: Vertical inertia forces associated with the vertical acceleration of the structure itself shall be taken equal to $0.2S_{DS}W$.

15.7.3 Strength and Ductility

Structural members that are part of the seismic force-resisting system shall be designed to provide the following:

a. Connections to seismic force-resisting elements, excluding anchors (bolts or rods) embedded in concrete, shall be designed to develop Ω_0 times the calculated connection design force. For anchors (bolts or rods) embedded in concrete, the design of the anchor embedment shall meet the requirements of Section 15.7.5. Additionally, the connection of the anchors to the tank or vessel shall be designed to develop the lesser of the strength of the anchor in tension as determined by the reference document or Ω_0 times the calculated anchor design force. The overstrength requirements of Section 12.4.3, and the Ω_0 values tabulated in Table 15.4-2, do not apply to the design of walls, including interior walls, of tanks or vessels.
b. Penetrations, manholes, and openings in shell elements shall be designed to maintain the strength and stability of the shell to carry tensile and compressive membrane shell forces.
c. Support towers for tanks and vessels with irregular bracing, unbraced panels, asymmetric bracing, or concentrated masses shall be designed using the requirements of Section 12.3.2 for irregular structures. Support towers using chevron or eccentric braced framing shall comply with the seismic requirements of this standard. Support towers using tension-only bracing shall be designed such that the full cross-section of the tension element can yield during overload conditions.
d. In support towers for tanks and vessels, compression struts that resist the reaction forces from tension braces shall be designed to resist the lesser of the yield load of the brace, $A_g F_y$, or Ω_o times the calculated tension load in the brace.
e. The vessel stiffness relative to the support system (foundation, support tower, skirt, etc.) shall be considered in determining forces in the vessel, the resisting elements, and the connections.
f. For concrete liquid-containing structures, system ductility, and energy dissipation under unfactored loads shall not be allowed to be achieved by inelastic deformations to such a degree as to jeopardize the serviceability of the structure. Stiffness degradation and energy dissipation shall be allowed to be obtained either through limited microcracking, or by means of lateral force resistance mechanisms that dissipate energy without damaging the structure.

15.7.4 Flexibility of Piping Attachments

Design of piping systems connected to tanks and vessels shall consider the potential movement of the connection points during earthquakes and provide sufficient flexibility to avoid release of the product by failure of the piping system. The piping system and supports shall be designed so as not to impart significant mechanical loading on the attachment to the tank or vessel shell. Mechanical devices that add flexibility, such as bellows, expansion joints, and other flexible apparatus, are permitted to be used where