4.5 BOCA AND SBC METHOD

4.5.1 Base Shear

$$V_I = C_{SI}(W_W + W_R + W_I) \qquad \text{Impulsive}$$

$$V_C = C_{SC}(W_C) \qquad \text{Convective}$$

$$C_{SI} = \frac{1.2A_V S}{RT_I^{2/3}} \le \frac{2.5A_a}{R} \qquad \text{Impulsive}$$

$$C_{SC} = \frac{1.2A_V S}{RT_C^{2/3}} \le \frac{2.5A_a}{R} \qquad \text{Convective}$$

Total base shear $V_T = \sqrt{V_I^2 + V_C^2}$

where A_a and A_v are the effective peak acceleration coefficient and the effective peak velocity-related acceleration coefficient, respectively (see Section 1610.1.3 of BOCA and Section 1607.1.5 of SBC)

The values of site coefficient (S) and response modification factor (R) should be taken from appropriate edition of the BOCA or SBC codes.

4.5.2 Overturning moment

$$M_I = C_{SI}(W_W h_W + W_R h_R + W_I h_I) \qquad \text{Impulsive}$$

$$M_C = C_{SC}(W_C h_C) \qquad \text{Convective}$$

Total overturning moment $M_T = \sqrt{M_I^2 + M_C^2}$

4.6 ACI 350.3-01 METHOD

The provisions of ACI 350.3[3-6] are to be used in conjunction with Chapter 21 (Special Provisions for Seismic Design) of ACI 350-01. These provisions are compatible with UBC 1994. Note that ACI 350-01 is based on ACI 318-95[4-3] for most of its design provisions and load combinations. Section 21.2.1.7 of ACI 350-01 indicates that the environmental durability factor (S) defined in Section 9.2.8 need not be applied to load combinations that include earthquake effects. The load combinations applicable under various Codes are given in Chapter 3 of this publication.

Where ACI 350-01 is adopted for use, the provisions of Chapter 21 along with ACI 350.3 and ACI 318-95 are applicable. Note that ACI 350.3 also gives recommendations for seismic zone factors (Z), and soil factors (S), which are mostly consistent with UBC 1994. The importance factors of ACI 350.3-01 are given in Table 4-1. ACI 350.3-01 also gives separate response modification factors R_{WI} and R_{WC} for impulsive and convective motions of the liquid-containing structure (Table 4-2.)

4.7 PERIOD

The equations for determining the impulsive period T_I and convective period T_C of rectangular and circular liquid-

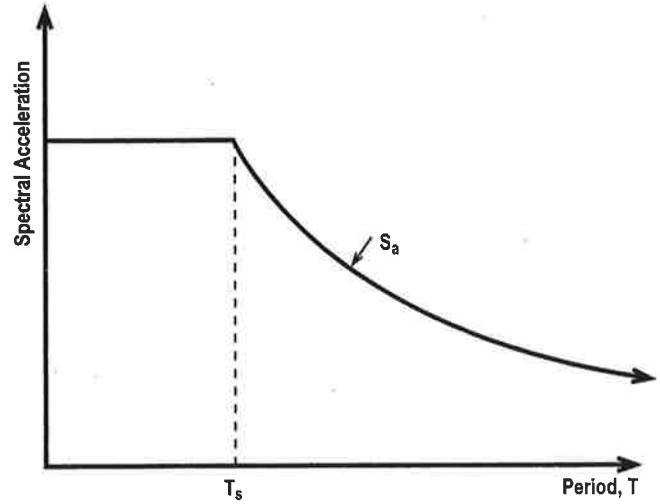

Fig. 4-8 Simplified Response Spectrum, UBC-1994

containing structures having different base conditions are given below. However, it is permitted to use any other rational method that includes a reasonable distribution of mass and stiffness characteristics for determining the natural period of the structure.

As most concrete tanks are relatively rigid, T_I may be taken as 0.3 seconds or less for the preliminary and approximate design calculations. It is recommended that for flexible base tanks, T_I should not exceed 1 second for anchored and unanchored contained tanks. This limit should not exceed 2 seconds for unanchored uncontained tanks. The limits on the periods suggested herein are to prevent excessive deformation of tanks.

4.7.1 Rectangular Tanks

The following equation can be used to determine the impulsive period of a rectangular tank:

$$T_I = 2\pi\sqrt{\frac{W}{gK}}$$

For fixed-base constant thickness cantilever walls:

$$K = \frac{E_C}{48}\left(\frac{t_w}{h}\right)^3$$

$$T_I = 2\pi\sqrt{\frac{m}{K}}$$

$$W = W_W + W_R + W_I \quad \text{(kips)}$$

where h = mean height (ft) at which the inertia force of the tank and its contents is assumed to act, t_w = wall thickness (in.), E_c = modulus elasticity of concrete (ksi) g = acceleration due to gravity (ft/sec^2) and K = stiffness coefficient (kips/ft).

The period associated with the convective component (T_C) can be determined as follows:

$$T_C = \frac{2\pi}{\lambda}\sqrt{L}$$