

1617.1.1.1 Seismic load effect, E . Where the effects of gravity and the seismic ground motion are additive, seismic load, E , for use in Equations 16-5, 16-10 and 16-17, shall be defined by Equation 16-50:

$$E = \rho Q_E + 0.2 S_{DS} D \quad \text{(Equation 16-50)}$$

horiz + vert.

where:

D = The effect of dead load.

E = The combined effect of horizontal and vertical earthquake-induced forces.

ρ = A redundancy coefficient obtained in accordance with Section 1617.2.

Q_E = The effect of horizontal seismic forces.

S_{DS} = The design spectral response acceleration at short periods obtained from Section 1615.1.3 or 1615.2.5.

Where the effects of gravity and seismic ground motion counteract, the seismic load, E , for use in Equations 16-6, 16-12 and 16-18 shall be defined by Equation 16-51.

$$E = \rho Q_E - 0.2 S_{DS} D \quad \text{(Equation 16-51)}$$

Design shall use the load combinations prescribed in Section 1605.2 for strength or load and resistance factor design methodologies, or Section 1605.3 for allowable stress design methods.

❖ An earthquake creates vibrational movement of the earth in all directions. Code writers have quantified this vibrational movement into the following formula:

$$E = \rho Q_E \pm 0.2 S_{DS} D$$

This formula can be broken down into two separate effects: one due to horizontal vibrational movement (ρQ_E) and the other due to vertical vibrational movement ($\pm 0.2 S_{DS} D$). All of the coefficients in this formula have been discussed earlier except for the reliability factor, which is discussed in Section 1617.2. In order to quantify E for the load combinations in Section 1605, one must complete the following steps:

Step 1: Determine axial force (P_{DL}), shear force (V_{DL}) and bending moment (M_{DL}) in element due to dead load.

Step 2: Determine axial force ($Q_{E(axial)}$), shear force ($Q_{E(shear)}$) and bending moment ($Q_{E(moment)}$) in element due to the design base shear, V , distributed as required in accordance with Section 1617.5.1.

Step 3: Create the table described in Figure 1617.1.1.1.

1617.1.1.2 Maximum seismic load effect, E_m . The maximum seismic load effect, E_m , shall be used in the special seismic load combinations in Section 1605.4.

Where the effects of the seismic ground motion and gravity loads are additive, seismic load, E_m , for use in Equation 16-19, shall be defined by Equation 16-52.

$$E_m = \Omega_0 Q_E + 0.2 S_{DS} D \quad \text{(Equation 16-52)}$$

Where the effects of the seismic ground and gravity loads counteract, seismic load, E_m , for use in Equation 16-20, shall be defined by Equation 16-53.

$$E_m = \Omega_0 Q_E - 0.2 S_{DS} D \quad \text{(Equation 16-53)}$$

where E , Q_E , S_{DS} are as defined above and Ω_0 is the system overstrength factor as given in Table 1617.6.2.

The term $\Omega_0 Q_E$ need not exceed the maximum force that can be transferred to the element by the other elements of the lateral-force-resisting system.

Where allowable stress design methodologies are used with the special load combinations of Section 1605.4, design strengths are permitted to be determined using an allowable stress increase of 1.7 and a resistance factor, ϕ , of 1.0. This increase shall not be combined with increases in allowable stresses or load combination reductions otherwise permitted by this code or the material reference standard except that combination with the duration of load increases in Chapter 23 is permitted.

❖ The maximum seismic load effect is required for the design of vulnerable elements critical to the stability of a structure. This maximum load effect generated in the structural and nonstructural components of a building can be much greater than those due to the design level force.

The overstrength factor, Ω_0 , increases the design level effects to represent the actual forces that may be

	APPLIED LOAD = DEAD LOAD	$0.2 S_{DS} D$	APPLIED LOAD = DESIGN BASE SHEAR, V	ρQ_E	E
Axial reaction	P_{DL}	$0.2 S_{DS} P_{DL}$	$Q_{E(AXIAL)}$	$\rho Q_{E(AXIAL)}$	$\rho Q_{E(AXIAL)} + 0.2 S_{DS} P_{DL}$ $\rho Q_{E(AXIAL)} - 0.2 S_{DS} P_{DL}$
Shear reaction	V_{DL}	$0.2 S_{DS} V_{DL}$	$Q_{E(SHEAR)}$	$\rho Q_{E(SHEAR)}$	$\rho Q_{E(SHEAR)} + 0.2 S_{DS} V_{DL}$ $\rho Q_{E(SHEAR)} - 0.2 S_{DS} V_{DL}$
Moment reaction	M_{DL}	$0.2 S_{DS} M_{DL}$	$Q_{E(MOMENT)}$	$\rho Q_{E(MOMENT)}$	$\rho Q_{E(MOMENT)} + 0.2 S_{DS} M_{DL}$ $\rho Q_{E(MOMENT)} - 0.2 S_{DS} M_{DL}$

**Figure 1617.1.1.1
SEISMIC LOAD EFFECT E**