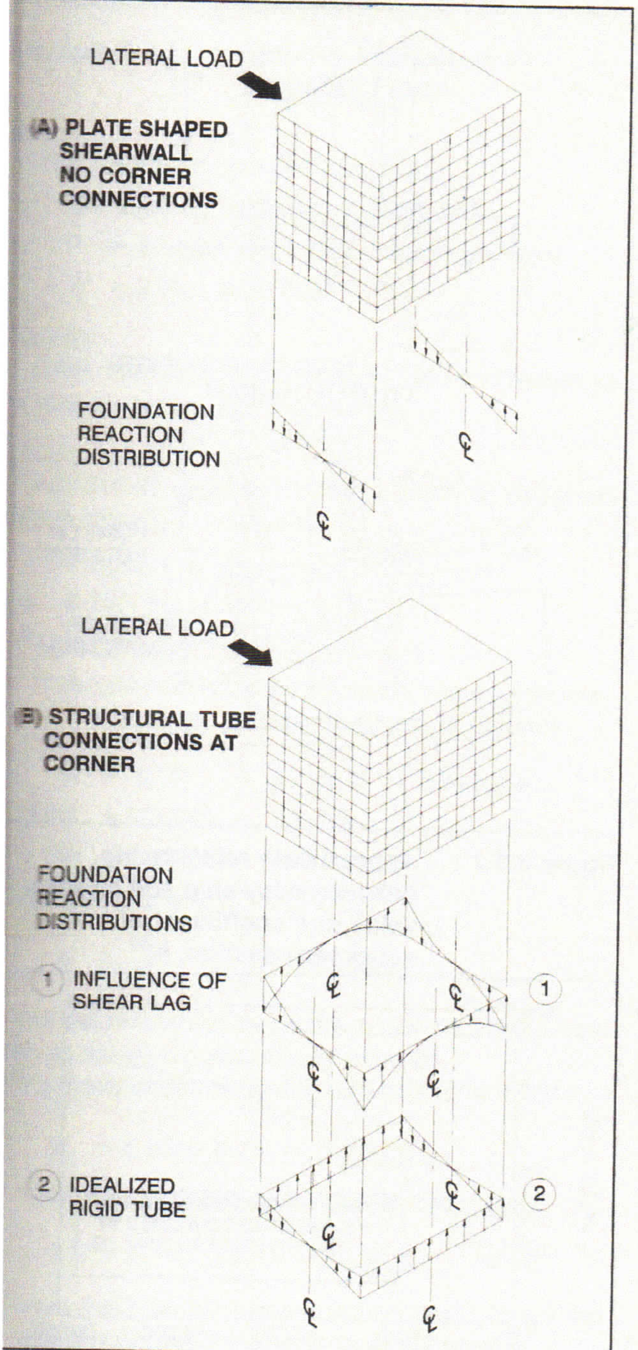
**Figure 3.7.17 Foundation reaction distributions resulting from lateral loads**




## 3.8 Moment-Resisting Building Frames

### 3.8.1 General

Precast, prestressed concrete beams and deck members are usually most economical when they can be designed and connected into a structure as simple-span members. This is because:

1. Positive moment-resisting capacity is much easier and less expensive to attain with pretensioned members than negative moment capacity at supports.
2. Connections which achieve continuity at the supports are usually complex and costly.
3. The restraint to volume changes that occurs in rigid connections may cause serious cracking and unsatisfactory performance or, in extreme cases, even structural failure.

Therefore, it is most desirable to design precast, prestressed concrete structures with connections which allow lateral movement and rotation, and to design the structure to achieve lateral stability through the use of floor and roof diaphragms and shear walls.

However, in some structures, adequate shear walls interfere with the function of the building, or are more expensive than alternate solutions. In these cases, the lateral stability of the structure depends on the moment-resisting capacity of either the column bases, a beam-column frame, or both.

When moment connections between beams and columns are required to resist lateral loads, it is desirable to make the moment connection after most of the dead loads have been applied. This requires careful detailing, specification of the construction process, and inspection. If such details are possible, the moment connections need only resist the negative moments from live load, lateral loads and volume changes, and will then be less costly.

### 3.8.2 Moment Resistance of Column Bases

Buildings without shear walls may depend on the fixity of the column base to resist lateral loads. The ability of a spread footing to resist moments caused by lateral loads is dependent on the rotational characteristics of the base. The total rotation of the column base is a function of rotation between the footing and soil, bending in the base plate, and elongation of the anchor bolts, as shown in Figure 3.8.1.

The total rotation of the base is:

$$\phi_b = \phi_f + \phi_{bp} + \phi_{ab} \qquad \text{(Eq. 3.8.1)}$$

If the axial load is large enough so that there is no tension in the anchor bolts, $\phi_{bp}$ and $\phi_{ab}$ are zero, and:

$$\phi_b = \phi_f \qquad \text{(Eq. 3.8.2)}$$

Rotational characteristics can be expressed in terms of flexibility or stiffness coefficients:

$$\phi = \gamma M = M/K \qquad \text{(Eq. 3.8.3)}$$

where:

$M$ = applied moment = $Pe$

$e$ = eccentricity of the applied load, $P$

$\gamma$ = flexibility coefficient

$K$ = stiffness coefficient = $1/\gamma$

If bending of the base plate and strain in the anchor bolts are assumed as shown in Figure 3.8.1, the flexibility coefficients for the base can be derived, and the total rotation of the base becomes:

$$\phi_b = M(\gamma_f + \gamma_{bp} + \gamma_{ab})$$

$$= Pe(\gamma_f + \gamma_{bp} + \gamma_{ab}) \quad \text{(Eq. 3.8.4)}$$

$$\gamma_f = \frac{1}{k_s I_f} \quad \text{(Eq. 3.8.5)}$$

$$\gamma_{bp} = \frac{(x_1 + x_2)^3[2e/(h + 2x_1) - 1]}{6eE_s I_{bp}(h + x_1)} \geq 0 \quad \text{(Eq. 3.8.6)}$$

$$\gamma_{ab} = \frac{g[2e/(h + 2x_1) - 1]}{2eE_s A_b(h + x_1)} \geq 0 \quad \text{(Eq. 3.8.7)}$$

where:

$\gamma_f$ = flexibility coefficients of footing/soil interaction

$\gamma_{bp}$ = flexibility coefficients of base plate

$\gamma_{ab}$ = flexibility coefficients of anchor bolts

$k_s$ = coefficient of subgrade reaction from Figure 3.8.2

$\ell_f$ = moment of inertia of the footing (plan dimensions)

$E_s$ = modulus of elasticity of steel

$I_{bp}$ = moment of inertia of the base plate (vertical cross-section dimensions)

$A_b$ = total area of anchor bolts in tension

$h$ = width of column in direction of bending

$x_1$ = distance from face of column to the center of the anchor bolts, positive when anchor bolts are outside the column, and negative when anchor bolts are inside the column

$x_2$ = distance from the face of the column to base plate anchorage

$g$ = assumed length over which elongation of the anchor bolt takes place = ½ of development length + projection for anchor bolts made from reinforcing bars, or the length to the hook + projection for smooth anchor bolts (see Figure 3.8.1)

**Figure 3.8.1 Assumptions used in derivation of rotational coefficients for column bases**

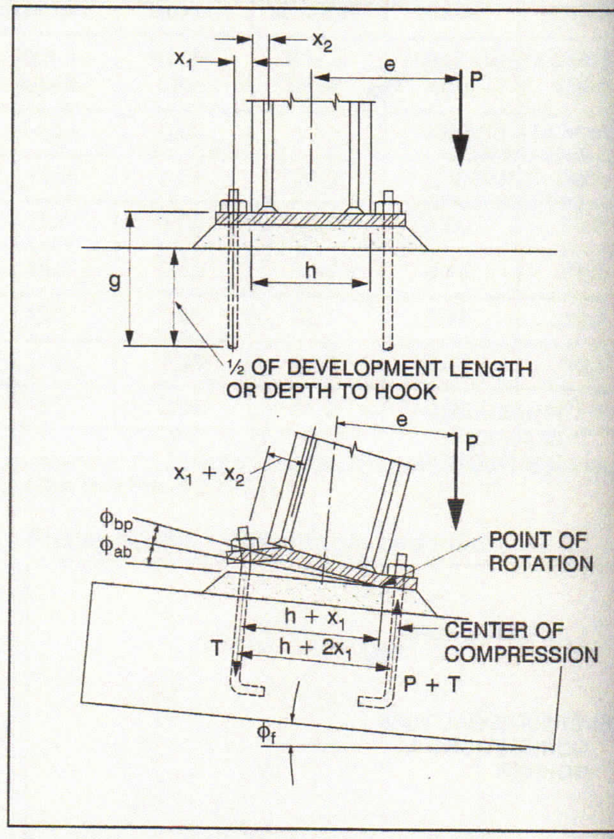
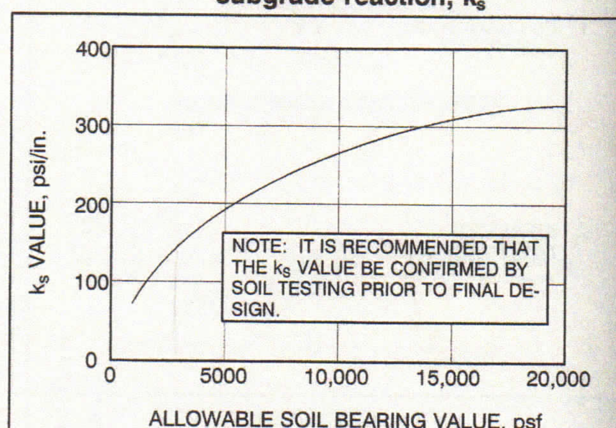



**Figure 3.8.2 Approximate relationship between allowable soil bearing value and coefficient of subgrade reaction, $k_s$**




Rotation of the base may cause an additional eccentricity of the loads on the columns, causing moments which must be added to the moments induced by the lateral loads.

Note that in Eqs. 3.8.6 and 3.8.7, if the eccentricity, $e$, is less than $h/2 + x_1$ (inside the center of compression), $\gamma_{bp}$ and $\gamma_{ab}$ are less than zero, meaning that there is no rotation between the column and the footing, and only the rotation from soil deformation (Eq. 3.8.5) need be considered.