CHAPTER 3 – STRUCTURAL CAPACITY OF DRILLED SHAFTS

3.1 AXIAL LOAD

Procedures for evaluating the structural capacity of drilled shafts by Reese and O'Neill and in ACI 318-05 are outlined in this section. For a concrete column subjected only to compressive axial load, the maximum load allowed based on ACI Section 10.3.6.2 is given by (ACI Eq. 10-2):

$$\phi P_n = \beta\phi\left[\left(0.85 f_c'\right)\left(A_g - A_s\right) + f_y A_s\right] \qquad \text{(Eq. 31)}$$

where

ϕP_n = factored load applied to the column that is computed from structure analysis

P_n = nominal strength of the column cross section

ϕ = strength-reduction factor

β = reduction factor to account for the possibility of small eccentricities of the axial load,

$\beta = 0.85$ for spiral columns and $\beta = 0.8$ for tied columns

f_c' = compressive strength of the concrete cylinder

A_g = gross cross-sectional area of the concrete section

A_s = cross-sectional area of the longitudinal reinforcement

f_y = yield strength of the longitudinal reinforcement

In the case of the concentric anomalies in which the reinforcement is not embraced in concrete, the structural capacity is computed from the concrete with the anomaly alone by ignoring the capacity contribution from reinforcements for their minimal contribution due to buckling for reinforcement bars.

3.2 AXIAL LOAD AND BENDING MOMENT

In a drilled shaft with nonconcentric anomalies, the axial compressive force at a defective section will produce an eccentric moment. This reduces the axial structural capacity as a result of the interaction between the axial compressive force and the bending moment. The bending moment leads to extra flexural stresses beyond the stresses from the axial load. The interaction diagrams shown in Figure 30 can be calculated by using a series of strain distributions, each corresponding to a particular point on the axial force, P, versus the moment, M, diagram with a specific pair of axial load, $P_{n,}$, and moment, M_n , (MacGregor and Wight, 2005).

The nonconcentric anomaly is assumed to have the shape shown in Figure 31. The structural capacity of this anomaly can be calculated according to ACI 318-05, by the finite element method, or by the stress strain curves for concrete and steel (O'Neill and Reese, 1999).

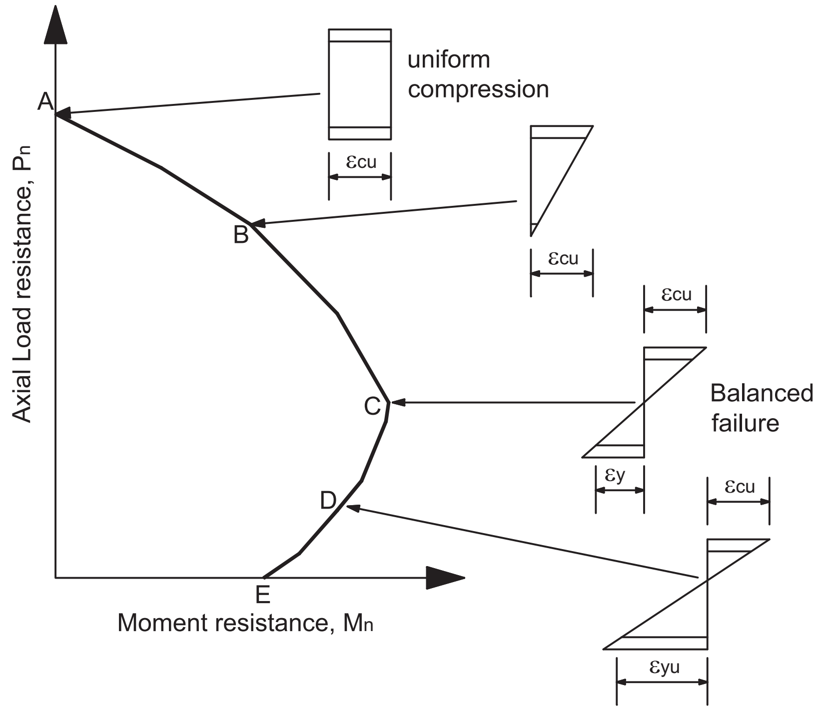

Figure 30. Strain distributions corresponding to the point on the P-M interaction diagram (McGregor and Wight, 2005).

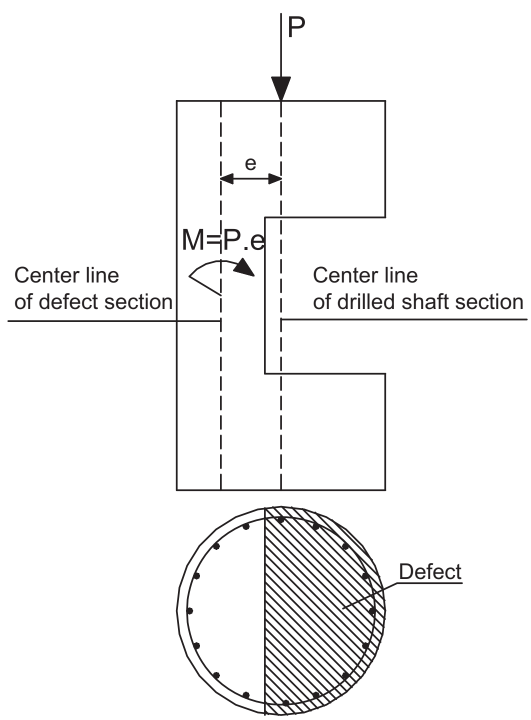

Figure 31. Nonconcentric anomaly.

The stress strain curve for concrete in Figure 32 is defined as follows:

$$f_c'' = 0.85 f_c' \qquad \text{(Eq. 32)}$$

$$f_c = f_c''\left[2(\varepsilon/\varepsilon_0) - (\varepsilon/\varepsilon_0)^2\right];\ \varepsilon < \varepsilon_0 \qquad \text{(Eq. 33)}$$

$$\varepsilon_0 = 1.7\, f_c'/E_c \qquad \text{(Eq. 34)}$$

Young's modulus:

$$E_c = 151000\sqrt{f_c'} \qquad \text{(Eq. 35)}$$

Tensile strength:

$$f_r = 19.7\sqrt{f_c'} \qquad \text{(Eq. 36)}$$

where E_c, f_c', f_c'', and f_r are in kPa.

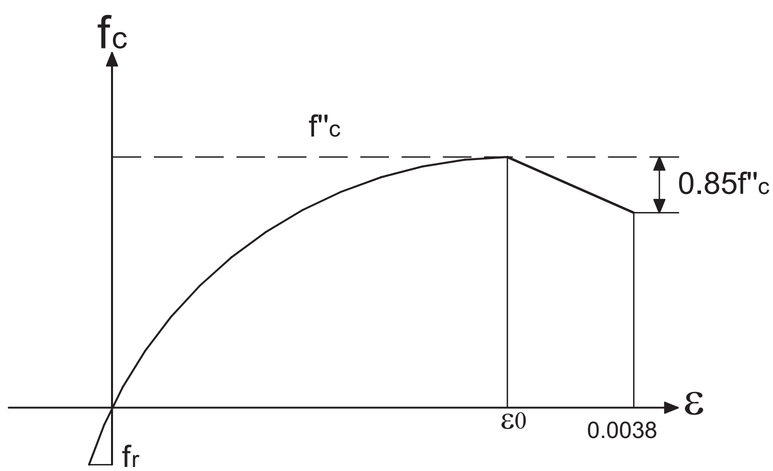

Figure 32. Stress strain curve for concrete (O'Neill and Reese, 1999).

The stress strain curve for reinforcement in Figure 33 is defined as follows:

$$\varepsilon_y = \frac{f_y}{E_y} \qquad \text{(Eq. 37)}$$

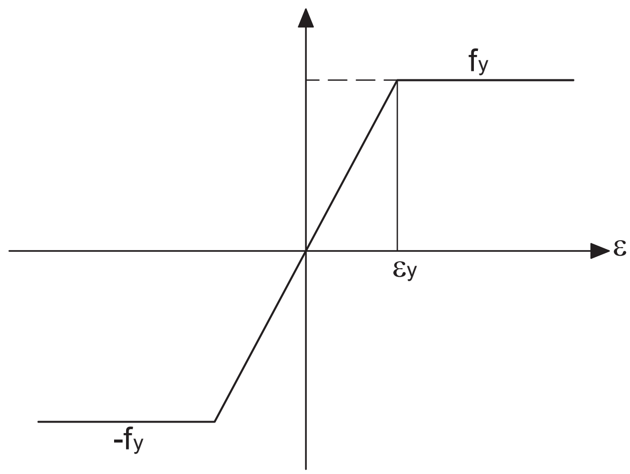

Figure 33. Stress strain curve for steel (O'Neill and Reese, 1999).

The following procedures as presented by O'Neill and Reese (1999) are used to compute the axial load and the moment on the interaction diagram:

- Cross section is divided into the finite strips shown in Figure 34.
- Apply the rotation, r, and the axial strain, ε, representing the moment and the axial load.
- Assume the position of the neutral axis and then the strain of each strip can be calculated by: $\varepsilon_i = \varepsilon + rd_i$, where d_i is the distance from the center of a strip to the neutral axis. From the value of these strains, the forces in each strip are calculated. The sum of these forces must be equal to the applied axial force. If this condition is not satisfied, the process is repeated by moving the position of the neutral axis.
- The bending moment is then computed by summing the moments from all of the normal forces from all of the strips about the neutral axis.

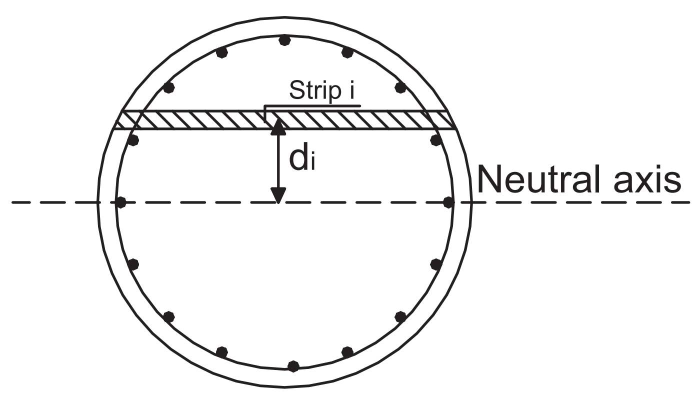

Figure 34. Finite strips of cross section.