Appendix D Example 27 – Pile Penetration Failure – Type I Bent

Refer to *Falsework Manual,* Section 8-6.06A, *Failure to Attain Required Penetration.* When the D/H ratio is less than 0.75 but greater than or equal to 0.45 for pile foundations an alternative procedure is used for analysis of piles (Ref Section 8-6.06A). This condition will increase rotation of the falsework bent which will reduce bending resistance and overall load-carrying capacity. This example demonstrates the alternate procedure for pile analysis.

Given Information

Refer the example in Section D-24, *Type I Bent,* and assume the pile failed to reach its required minimum depth (D) of 9-feet (Refer to Section 8-6.04A).

Revised design using the same 12″ piles but penetrating only 7.5-feet. Assume the same pile pull or pile lean values.

Determine Adequacy of Pile

1. Find new value for L_2 - See Section 8-6.06A(1)

   New $\frac{D}{H} = \frac{7.5}{12} = 0.625$

   From Figure 8-29, Q = 1.10 (for normal soil)

   Y_2 = 4dR = $4\left(\frac{12}{12}\right)(1.25) = 5.00$ ft (see example 24)

   New L_2 = H + (Q)(Y_2) = 12 + (1.10)(5.00) = 17.50 ft

2. Recalculate $f_{bp(2)}$ using new L_2

   $$F_2 = \frac{3EI\triangle}{(12L_2)^3} = \frac{3\left(1.7 \times 10^6\right)(1018)(4)}{\{(12)(17.50)\}^3} = 2242 \text{ lb}$$

   $$f_{bp(2)} = \frac{F_2(12L_2)}{S} = \frac{(2242)(12)(17.50)}{170} = 2770 \text{ psi}$$

3. Check bent type

   New L_u = 2.0 + new Y_2 = 2.0 + (1.10)(5.00) = 7.5 ft

   $\frac{L_u}{d} = \frac{7.50 \text{ x } 12}{12} = 7.50 < 8.0$ Type I bent

4. Evaluate system adequacy

   $f_{be(1)}$ and f_c are unchanged (see Example 24)

   L_u (in longitudinal direction governs) = L_2 = 17.50 ft

   Equivalent d = 10.39 in (see Example 24)

   Capacity in compression:

   Reference design value in compression F_c = 1300 psi (NDS supplement table 6A)

   Adjustment factors from NDS table 6.3.1:

C_D = 1.25	*Duration Factor for 2% lateral loading*
C_M = 1.0	*Wet Service Factor NDS 6.3.3*
C_t = 1.0	*Temperature Factor NDS 6.3.4 (Temp up to 100ºF)*
C_{ct} = 1.0	*Conditioning Treatment Factor NDS 6.3.5 (air dried)*
C_{cs} = 1.01	*Critical Section Factor NDS 6.3.9 (L_c = 2.50 ft)*
C_P = 0.615	*Column Stability Factor NDS 3.7.1 (Eff length* $17.50\ ft$*)*
C_{ls} = 1.11	*Load sharing Factor NDS 6.3.11*

   Adjusted design compression value $F_c' = F_c (C_D)(C_M)(C_t)(C_{ct})(C_{cs})(C_P)(C_{ls})$ = 1120 psi

Solve combined stress expression (Type I)

F_b' = 2768 psi (See example problem D-24)

$$\frac{f_{bp(2)}+2f_{be(1)}}{3F'_b} + \frac{2f_c}{3F'_c} \leq 1.0$$

$$\frac{2770+2(988)}{3(2768)} + \frac{2(372)}{3(1120)} = 0.57 + 0.22 = 0.79 \leq 1.0$$ OK