Calculation_For := " Cleveland Innerbelt Main Viaduct Pier No. 7 Footing "

DESIGNER NOTE:

-The number of shear studs connectors will be determined by the structural capacity of the studs, and then the shear friction of the studs with concrete will be checked.

SHEAR STUD DESIGN FOR TENSION IN PILE: (LRFD 6.10.4.4.3)

REVISED

By: DSB 6/21/11
Ck: KDG 6/30/11
Bck: DSB 7/1/11

REVISED FOR RFI 132

By: KDG 10/10/11
Ck: DSB 10/11/11
Bck: KDG 10/11/11

Inputs are boxed

$f'_c := 4000 \cdot psi$ Compressive Strength of Concrete in 28-days

$f_{y\_stud} := 50 \cdot ksi$ Yield Strength of Shear Studs, Grade 50

$F_u := 60 \cdot ksi$ Minimum tensile strength for Shear Stud Connectors (LRFD 6.4.4)

$d := \frac{3}{4} in$ Diameter of Stud

$w_c := .145 \cdot \frac{kip}{ft^3}$ Unit Weight of Concrete in Pounds per cubic foot, $\frac{kip}{ft^3}$

$\phi_v := 0.90$ Reduction Factor - LRFD 5.5.4.2.1

$\phi_{sc} := 0.85$ Reduction Factor - LRFD 6.5.4.2

$P_{pile\_max} := 92 \cdot kips$ Worst Case Scenerio for Maximum Applied Tension in Pile provided by **AEC**. (Pier No. 7 load case 12210 - (Str I) Footing No.1)

$K_1 := 1.0$ LRFD 5.4.2.4

$$E_c := 33000 \cdot K_1 \cdot \left(\frac{w_c}{\frac{kip}{ft^3}} \right)^{\frac{3}{2}} \cdot \sqrt{\frac{f'_c}{ksi}} \cdot ksi \qquad E_c = 3.644 \times 10^3 \cdot ksi$$

(LRFD EQ. 5.4.2.4-1) Modulus of Elasticity of Concrete

$E_s := 29000 ksi$ Modulus of Elasticity of Shear Stud Connector

$$A_{sc} := \frac{\pi \cdot d^2}{4} \qquad A_{sc} = 0.442 \cdot in^2$$

Cross-Sectional Area of a Stud Shear Connector.

For H/d > 4 =====>>> $H := 4 \cdot d$ $\qquad H = 3 \cdot in$ Height of Shear Stud Connector (LRFD 6.10.10.1.1)

Use H = 4.0 in

-Ultimate Strength of the Shear Stud Connector, Q_n:

$Q_n := \min\left(0.5 \cdot A_{sc} \cdot \sqrt{f'_c \cdot E_c}, A_{sc} \cdot F_u\right)$ (LRFD EQ. 6.10.10.4.3)

$Q_n = 26.507 \cdot kip$

$Q_r := \phi_{sc} \cdot Q_n$ $Q_r = 22.531 \cdot kip$ (LRFD EQ. 6.10.10.4.1)

-Number of Shear Stud Connectors Required for Tension in the Piles: (LRFD EQ. 6.10.10.4.1-2)

$N_{studs} := \mathrm{ceil}\left(\frac{P_{pile\_max}}{Q_r}\right)$ $N_{studs} = 5$ Numbers of Shear Stud Connector

Use a 9 Shear Stud Connectors Per Flange. Thus, a Total of 18 Shear Connectors (3 rows of 3) with a center-to-center Spacing of 6 inches vertical and 6 inches horizontal (+/-) between shear connectors and edge distance of 3 inches from the top.

$N_{design} := 18$ $S_{studs} := 6in$ $S_{studs\_edge\_top} := 3in$ $S_{studs\_edge\_bot} := 6in$

$S_{studs\_center\_to\_center\_min} := 4 \cdot d$ $S_{studs\_center\_to\_center\_min} = 3 \cdot in$ (LRFD 6.10.10.1.3)

check_spacing_btwn_studs := if($S_{studs} \geq S_{studs\_center\_to\_center\_min}$, "O.K.", "increase Spacing btwn. Shear Studs")

check_spacing_btwn_studs = "O.K."

SHEAR FRICTION CHECK: (LRFD 5.8.4)

$\mu := 0.7$ Coefficient of Friction for Concrete Anchored to as-Rolled Structural Steel by Headed Studs. (LRFD 5.8.4.3)

$K_1 := 0.2$ Fraction of Concrete strength available to resist interface shear, as specified in LRFD 5.8.4.3

$K_2 := 0.8$ Limiting interface shear specified in LRFD 5.8.4.3

$c := 0.025 \cdot ksi$ Cohesion factor specified in LRFD 5.8.4.3

$P_c := 0.0 \cdot kip$ Permanent net compressive force normal to the shear plane

$A_{cv} := (8 \cdot ft + 9 \cdot in) \cdot (1 \cdot ft + 3 \cdot in)$ $A_{cv} = 10.938\, ft^2$ Area of Concrete Resisting Shear. Using only the concrete enclosed area surrounding the pile.

$A_{vf} := N_{design} \cdot A_{sc}$ $A_{vf} = 7.952 \cdot in^2$ Area of interface reinforcement shear reinforcement crossing the shear plane within the area A_{cv}.

-Shear Friction Capacity: (LRFD EQ. 5.8.4.1-3)

$V_{ni\_1} := c \cdot A_{cv} + \mu \cdot (A_{vf} \cdot f_{y\_stud} + P_c)$ $V_{ni\_1} = \underline{317.7} \cdot kip$

$V_{ni\_2} := K_1 \cdot f'_c \cdot A_{cv}$ $V_{ni\_2} = \underline{1.26} \times \underline{10^3} \cdot kip$

$V_{ni\_3} := K_2 \cdot A_{cv} \cdot ksi$ $V_{ni\_3} = \underline{1.26} \times \underline{10^3} \cdot kip$

$V_n := \min(V_{ni\_1}, V_{ni\_2}, V_{ni\_3})$

$\phi_v \cdot V_n = \underline{285.93} \cdot kips$

$check_{shear\_friction} := if(\phi_v \cdot V_n \geq P_{pile\_max}, \text{"O.K."}, \text{"No Good"})$ $check_{shear\_friction} = \text{"O.K."}$

SHEAR STUDS DETAIL