

PIPELIFE PRO40 MANHOLE COMPONENT UPLIFT EVALUATION

1.0 PROBLEM DISCUSSION

PIPELIFE PRO MANUFACTURER'S PLASTIC PIPING SYSTEMS FOR NON-PRESSURE UNDERGROUND DRAINAGE AND SEWER SYSTEMS. THE SYSTEM IS COMPRISED OF RELATIVELY LIGHTWEIGHT COMPONENTS. THE PURPOSE OF THIS CALCULATION IS TO DETERMINE THE FACTOR OF SAFETY AGAINST UPLIFT WHEN THE MANHOLE COMPONENT OF THE SYSTEM IS SUBMERGED BELOW GROUNDWATER.

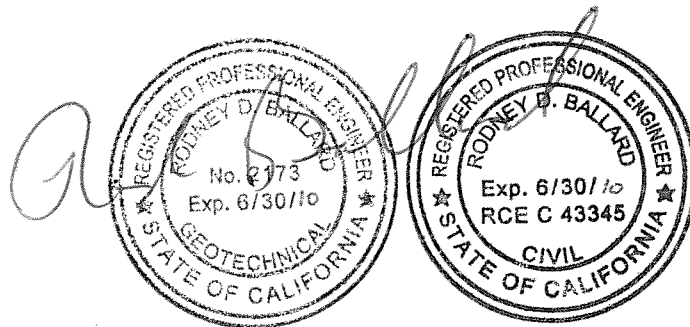
2.0 ASSUMPTIONS

- WEIGHT OF WATER = $\gamma_w = 62.4 \text{ LB/CF}$
- DEPTH TO GROUNDWATER = 0'
- HEIGHT OF MANHOLE = H
- PRO40 MANHOLE BASE, RISER RINGS, AND GASKET COMPONENTS ID = 39.4 O.D. = 43.7
- HIGH DENSITY PLASTIC SPECIFIC GRAVITY > 1.0 THEREFORE WEIGHT NEGLECTED

MATERIAL PROPERTIES

ASSUME USE OF CIVIL ENGINEERING REFERENCE MANUAL TABLE 35.10 AND TABLE 35.12. MATERIAL PROPERTIES UTILIZED ARE SUMMARIZED BELOW

MATERIAL	CLASS	PCF γ_d	COMP %	W_s %	PCF γ_s	ϕ'	$C's$ psf
POORLY GRADED GRAVEL	GP	120	94	14	128	37	0
POORLY GRADED SAND	SP	110	95	21	126	37	0
SILT	SM	107	96	14	127	32	190
CLAY	CL	107	96	24	127	28	270



3.0 UPLIFT FORCE DETERMINATION

$$U_F = \gamma_w H A$$

WHERE

$$\gamma_w = \text{WEIGHT OF WATER} = 62.4 \text{ PCF}$$

$$H = \text{HEIGHT OF MANHOLE} = \text{VARIABLE}$$

$$A = \text{INSIDE AREA OF MANHOLE BASE} = \pi (39.4/12)^2/4 = 8.5$$

$$\begin{aligned} U_F &= 62.4 (H) 8.5 \\ &= (528 \text{ LB/FT}) (H) \end{aligned}$$

4.0 RESISTING FORCE DETERMINATION

$$\begin{aligned} R_F &= \text{PULLOUT RESISTANCE OF MANHOLE} \\ &= \text{SIDE FRICTION} + \text{SOIL WEIGHT ABOVE FINS} \end{aligned}$$

$$R_F = K_o \gamma_b (H/2) A_o \text{ TAN } \phi + A_o (C_s) + [A_o - A_i] H \gamma_b$$

WHERE

$$\gamma_b = \text{BUOYANT SOIL WEIGHT} = \gamma_{\text{SAT}} - \gamma_w$$

$$H = \text{HEIGHT OF MANHOLE VARIABLE}$$

$$A_o = \text{OUTSIDE AREA OF MANHOLE SHAFT} = 11.4(H)$$

$$A_i = \text{INSIDE AREA OF MANHOLE SHAFT} = 10.3(H)$$

$$\text{TAN } \phi = \text{EFFECTIVE SHEAR STRENGTH}$$

$$C_s = \text{SATURATED COHESION (PSF)}$$

$$K_o = \text{AT REST PRESSURE COEFFICIENT} = 1 - \text{SIN } \phi$$

5.0 FACTOR OF SAFETY DETERMINATION

$$FS = R_F/U_F$$

GRAVEL @ H = 5.0

$$\begin{aligned} FS &= [(1 - \sin 37^\circ) (128 - 62.4) (5/2) (11.4) (5) \tan 37^\circ \\ &+ (11.4) (0) + (11.4 - 10.3) (5) (128 - 62.4)] / [528 (5)] \\ &= [2804 + 0 + 361]/2640 \\ &= 1.2 \end{aligned}$$

GRAVEL @ H = 10.0

$$\begin{aligned} FS &= [11219 + 0 + 721]/5280 \\ &= 2.3 \end{aligned}$$

SAND @ H = 5.0

$$\begin{aligned} FS &= [(1 - \sin 37^\circ) (126 - 62.4) (5/2) (11.4) (5) \tan 37^\circ \\ &+ 0 + (11.4 - 10.3) (5) (126 - 62.4)] / [528 (5)] \\ &= [2719 + 0 + 350]/2640 \\ &= 1.2 \end{aligned}$$

SAND @ H = 10.0

$$\begin{aligned} FS &= [10877 + 0 + 700]/5280 \\ &= 2.2 \end{aligned}$$

SILT @ H = 5.0

$$\begin{aligned} \text{FS} &= [(1 - \sin 32^\circ) (127 - 62.4) (5/2) (11.4) (5) \tan 32^\circ \\ &+ (11.4) (5) (190) + (11.4 - 10.3) (5) (127 - 62.4)] / [528 (5)] \\ &= [2704 + 10830 + 355] / 2640 \\ &= 5.2 \end{aligned}$$

SILT @ H = 10.0

$$\begin{aligned} \text{FS} &= [10816 + 21660 + 710] / 5280 \\ &= 6.3 \end{aligned}$$

CLAY @ H = 5.0

$$\begin{aligned} \text{FS} &= [(1 - \sin 28^\circ) (127 - 62.4) (5/2) (11.4) (5) \tan 28^\circ \\ &+ (11.4) (5) (270) + (11.4 - 10.3) (5) (127 - 62.4)] / [528 (5)] \\ &= [2596 + 15390 + 355] / 2640 \\ &= 6.9 \end{aligned}$$

CLAY @ H = 10.0

$$\begin{aligned} \text{FS} &= [10384 + 30780 + 710] / 5280 \\ &= 7.9 \end{aligned}$$

6.0 CONCLUSION

BASED ON THE ABOVE EVALUATION, THE MANHOLE SYSTEM HAS A MINIMUM FACTOR OF SAFETY AGAINST UPLIFT OF AT LEAST 1.2 WHEN INSTALLED TO A DEPTH OF FIVE FEET ASSUMING THE WATER TABLE IS LOCATED AT GROUND SURFACE (EXTREMELY CONSERVATIVE). FURTHERMORE, THE FACTOR OF SAFETY INCREASES APPRECIABLY WITH INCREASED DEPTH.