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Steel Buoyancy of Cast-in-Place Piles, Study and Behavior through Mistake Design of Longitudinal Steel Bars Area and Basket Spiral Mesh Pitch

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Abstract
Some regions require deep foundation in the SW of Iran. Low resistances soils are forced to build various types of steel pipe, concrete precast and cast- in- place piles. Cast-in-place piles are used through suitable section area and required length in depth that length will vary from 10m to 45m. Longitudinal steel bars could be floated in the well to lift the spiral basket by injection pipe pressure of fresh concrete. Buoyancy forces could be exerted to destroy the top platform and steel mesh. Sometimes it is observed to lift the loader wheels and steel falling hammer. This event appears the negative psychological effects in the workshop. Expert workers are believed uncertainly ideas that unknown problems will refer to concrete mixture, drilling without casing and liquid circulation of pile hole. Also, the main problem will refer to the spiral mesh and steel bar section area. Steel floating could be interpreted by pervious problems. Solutions will be suggested to control the ρ (relative steel section area) through the length of the pile and spiral could be started at 100cm above the pile tip. Fresh concrete slump will be used more than 25cm. Circulation will be continued to end of concreting.

Keywords
Floating, Spiral basket, Cast-in-place pile

1. Introduction

Ahvaz city is located in the SW of the Persian Gulf. The Karun River currents through the Ahvaz with 300m width and 20km tangency beach in the heart of city. In 1942 Black Bridge was constructed over the Karun River in truss structures using the German military engineering. In 1998 the Seventh Bridge was built by Iranian contractors near the old Black Bridge (700m distance) and over the Karun with concrete box system and 400m width. In 1997 Ahvaz Municipality was contracted to build the two new bridges in road path of both Black and Seventh bridges (KDH, 1997). Both bridges are intersected into the main north southern boulevard in Ahvaz where intersection points of new bridges are designed to reduce the traffic loads. Foundations of bridges were designed by cast-in-place piles which will be constrained to transfer the load from composite deck into circular columns and pile cap (PEYKAV, 1997).

During the casting concrete, steel spiral mesh would be floated in the pile ditch. The exerted load was very high that could be distorted the steel spiral. Mentioned load was prohibited to fix in the depth by mass objects. The basket can elevate steel hammer and loader wheels.

Studies and researches could be interpreted the main cause that will apply in the pile mesh. Dynamic motion forces will be included to change the stability of spiral mesh. Truck mixer stands on the platform and concrete will discharge through mixer into the transferring pipe. Potential energy will convert to kinetic energy and steel mesh will raise upward (NOFAN, 2002). Simple methods would be suggested to decrease floating effects. Concrete slump can be increased to modified the undesired behavior by water and cement ratio (Puller, 2003). Details will be explained in the text.

2. Floating of Steel Mesh

Figures 1 to 3 will try to explain the floating behavior in pit piles that will be occurred through concreting of cast-in-place piles (Turk, 2001).

Figure 1: Installation of Steel Basket of Spiral Mesh in Pit Pile

Figure 2: Rotary Equipment for Cast-in-Place Piles

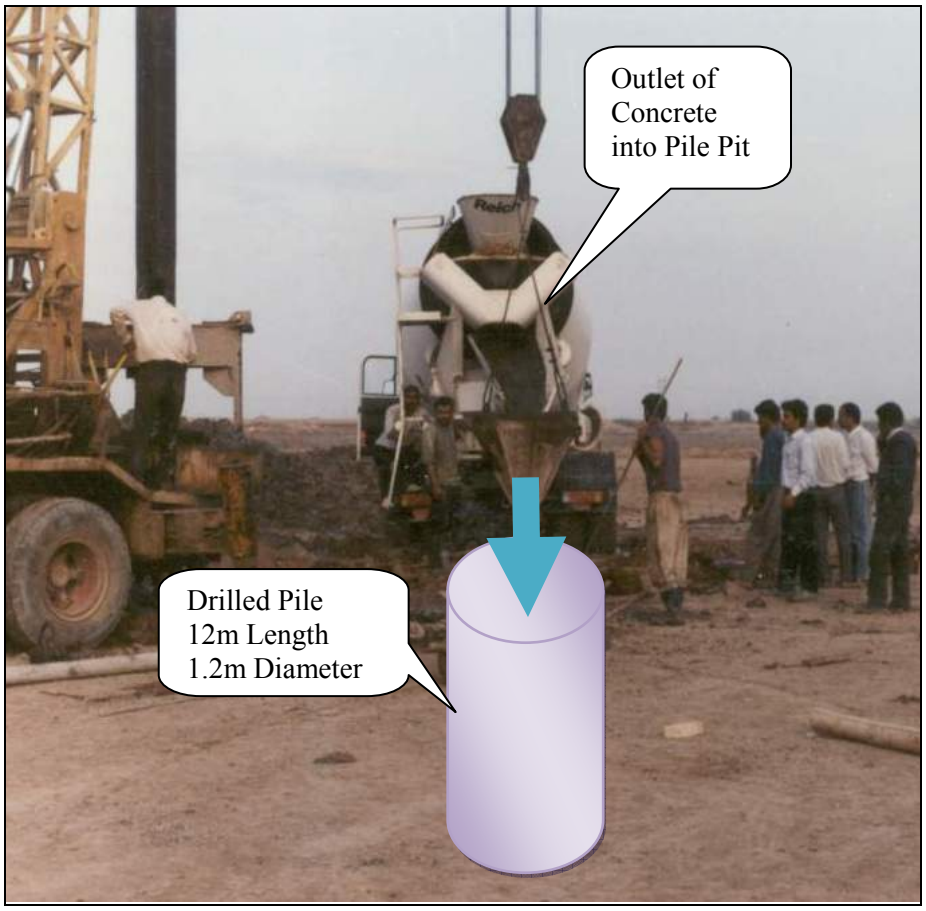

Figure 3: Installation of Spiral Basket by Crane

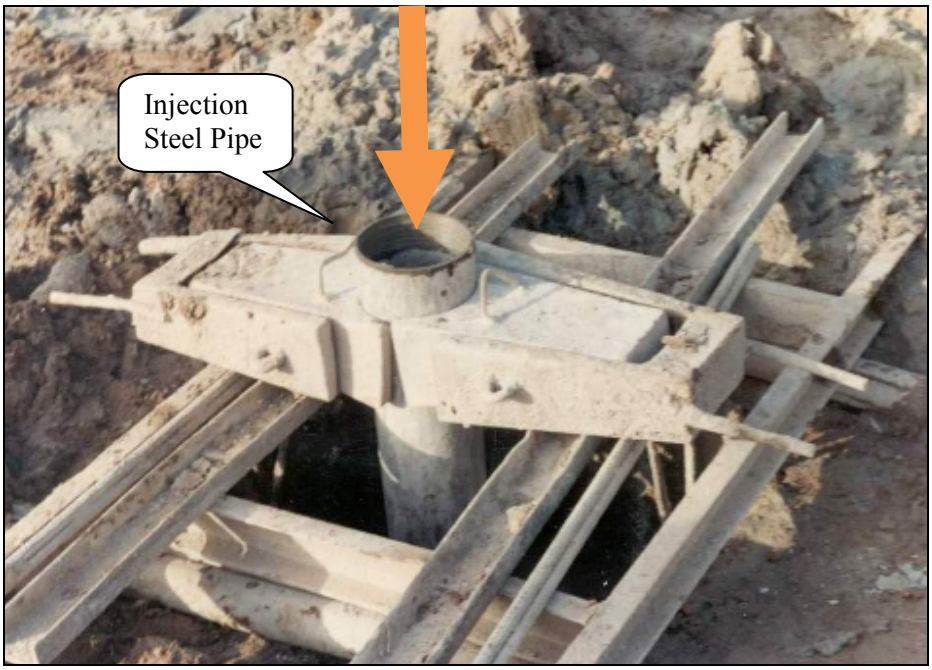

Figure 4: Injection Pipe of Concreting into Pile Pit from Truck Mixer

2.1 Extra Pressure in Tip Point

Dynamic energy will obtain from the truck mixer level that could be defined the top point of potential energy. Kinetic energy will produce the maximum velocity at pile pit point. The fresh concrete operation will demonstrate in the Figures 5 to 6. Also, extra stresses will be computed through Equations 1 to 15.

$$\left(E_C\right)_1 = \left(E_{Concrete}\right)_{level=0} = 0 \tag{1}$$

$$\left(E_C\right)_2 = \left(E_{Concrete}\right)_{level=-15.0m} \tag{2}$$

$$\left(\sigma_C\right)_2 = \gamma_{Concrete} \cdot \Delta H \tag{3}$$

$$\left(F_{SteelBars}\right)_2 = \gamma_C \cdot \Delta H \cdot A_{SteelBars} = 2'400\left(\frac{kg}{m^3}\right) \times \underbrace{\left(0.0 - \left(-15.00m\right)\right)}_{15.00m} \times 108\left(cm^2\right) = 388kg \tag{4}$$

$$\left(F_{Spiral}\right)_2 = \gamma_C \cdot \Delta H \cdot A_{Spiral} \cdot t \tag{5}$$

$$1cm = t \quad \Rightarrow$$

$$\left(F_{Spiral}\right)_2 = \gamma_C \cdot \Delta H \cdot A_{Spiral} \times 1cm = 2'400\left(\frac{kg}{m^3}\right) \times \underbrace{\left(0.0 - \left(-15.00m\right)\right)}_{15.00m} \times \underbrace{1.20\left(m\right) \cdot \pi}_{377cm^2} = 1357kg \tag{6}$$

$$\left(\sum F\right)_2 = 388 + 1357 = 1745kg \tag{7}$$

$$2cm = t \quad \Rightarrow$$

$$\left(F_{Spiral}\right)_2 = \gamma_C \cdot \Delta H \cdot A_{Spiral} \times 2 = \underbrace{2'400\left(\frac{kg}{m^3}\right)}_{\gamma_C} \times \underbrace{\left(0.0 - \left(-15.00m\right)\right)}_{\Delta H = 15.00m} \times \underbrace{1.20\left(m\right) \cdot \pi}_{A_{Spiral} = 377cm^2} \times 2 = 2714kg \tag{8}$$

$$\left(\sum F\right)_2 = 388 + 2'714 = 3'102kg \tag{9}$$

$$3cm = t \quad \Rightarrow \quad \left(\sum F\right)_2 = 388 + 1'357 \times 3 = 4'459kg$$

$$\left(W_{Steel}\right)_2 = \left(\gamma \cdot H \cdot A\right)_{Steel} = 7'800\left(\frac{kg}{m^3}\right) \times 12.00m \times 108cm^2 = 1'010kg \tag{10}$$

$$\left(W_{Spiral}\right)_2 = \left(\gamma \cdot \underbrace{L}_{20\frac{cm}{m} \cdot \pi D_{pile}} \cdot A\right) = \left(\gamma \cdot \underbrace{5\left(\frac{pitch}{m}\right)\pi D \cdot H}_{volume} \cdot \underbrace{\left(\frac{\pi}{4} d^2\right)}_{spiral}\right) \tag{11}$$

$$\left(W_{Spiral}\right)_2 = \left(\underbrace{7'800}_{\gamma} \times \underbrace{5 \times \pi \times 1.2m \times 12m}_{L=226m} \times \underbrace{\left(\frac{\pi}{4} 1.2^2\right)}_{1.13cm^2}\right) = 200kg$$

$$\Rightarrow \sum \left(W_{Spiral}\right)_2 = 1'010 + 200 = 1'210kg \tag{12}$$

$$\left(\sum F\right)_2 \langle \sum \left(W_{Spiral}\right)_2 \rightarrow 1745kg \rangle 1'210kg \Rightarrow Stability \tag{13}$$

$$\left(\sum F\right)_2 \rangle \sum \left(W_{Spiral}\right)_2 \rightarrow 1745kg \rangle 1'210kg \Rightarrow Floating \tag{14}$$

$$W_{Loader} = 2'000\,(kg) \rightarrow front\ axes$$

$$\left(\sum F\right)_2 \rangle \sum \left(W_{Spiral}\right)_2 \rightarrow (4'459kg) \rangle (1'210kg + 2'000kg = 3'210kg) \Rightarrow Floating \tag{15}$$

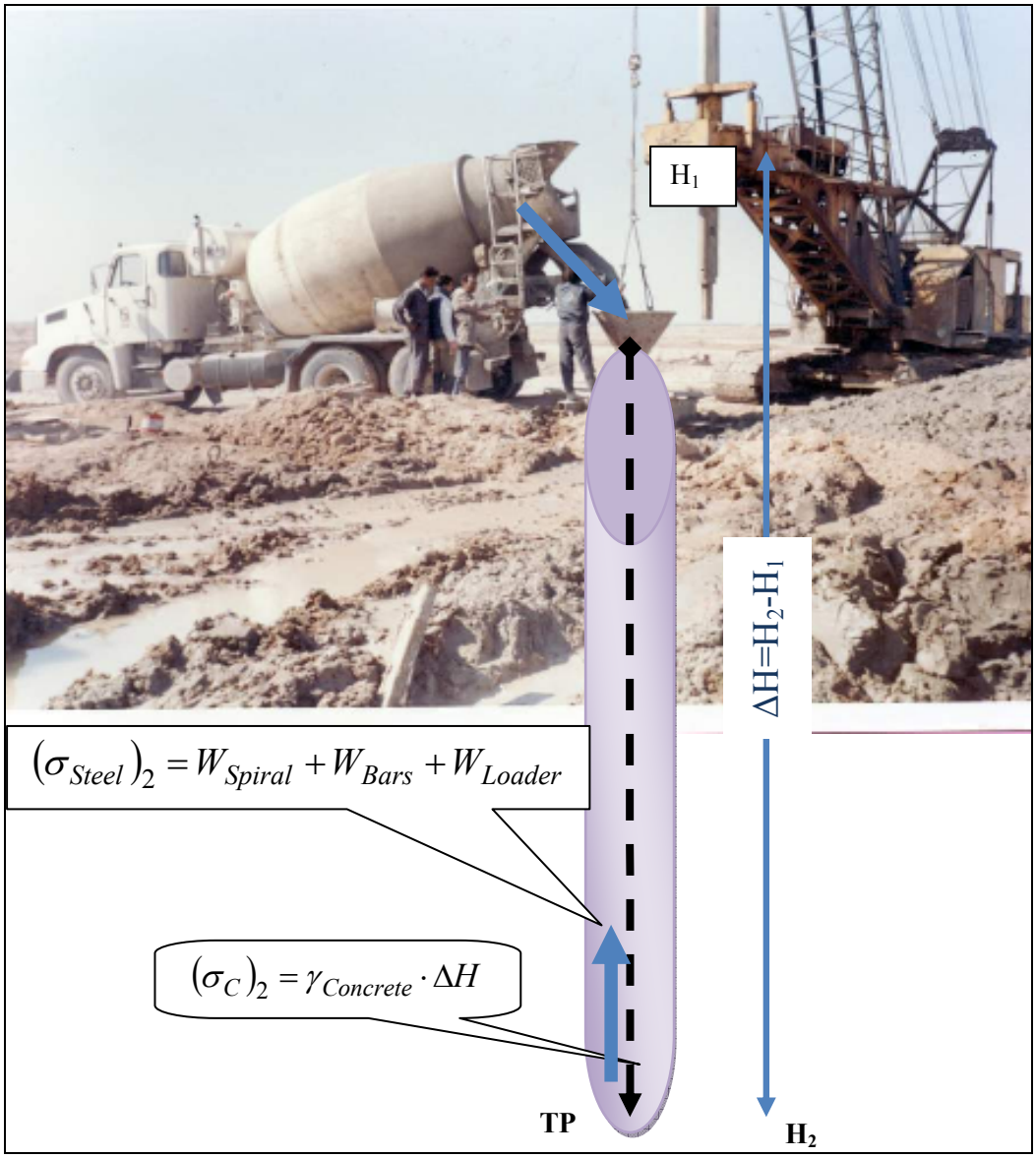

Figure 5: Height of Drilled Pile and Stresses with Vertical Elevation

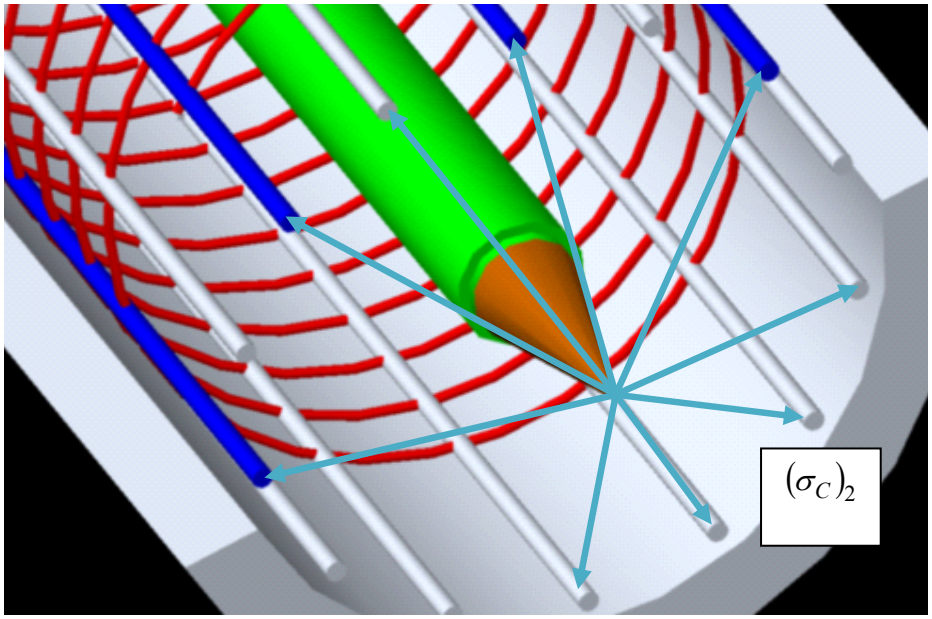

Figure 6: Stress Distribution of Concrete Injection on the Bar Steel Node (Equations 6 to 8)

3. Longitudinal Steel Bars Area

Steel bars and spiral mesh area will absorb the concrete pressure that would be floated the steel spiral basket in the pit through the no equilibrium of steel weights and concrete pressure. Figures 7 to 8 will demonstrate the node pressure on the center line of steel bars and first spiral turn.

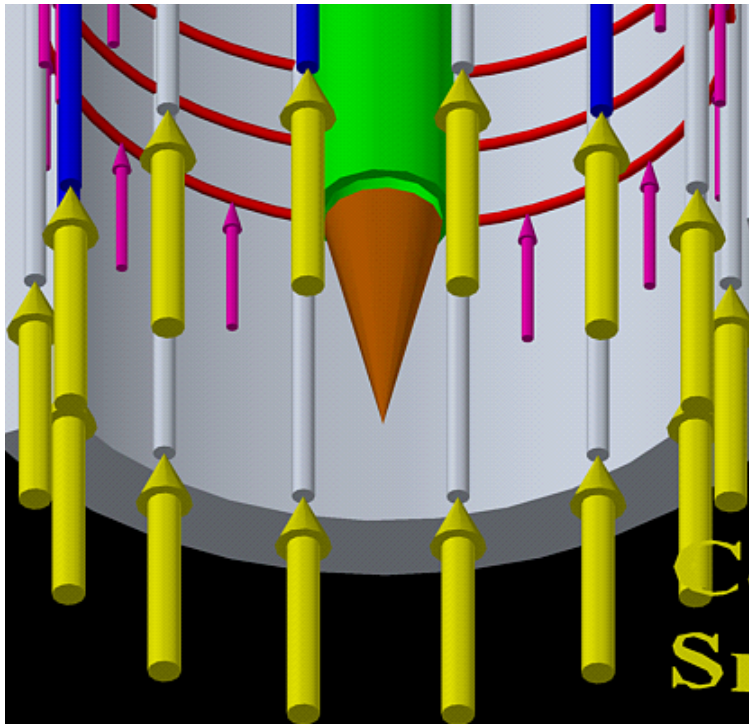

Figure 7: Node Pressure of Concrete on the Vertical Steel Bars and First Spiral Turn

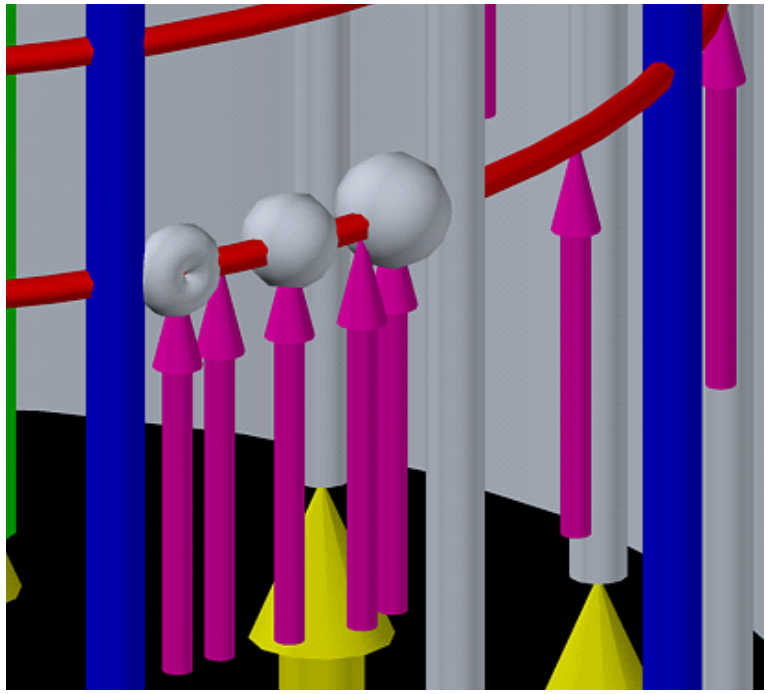

Figure 8: Concentrated Stresses on the First Spiral Turn by Random Concrete Aggregates

3.1 Steel Relative ρ

Relative area is defined to compute gross section area of longitudinal steel bars in the pile concrete section (Turk and Zaamari, 2004). Basic standard will define the designing methods of cast-in-place piles. Allowable stresses in concrete are less than the twenty percentage of maximum broken point of concrete cubic test. The ρ will design less than 2 percentage of effective section area of cast-in-place pile. Concrete cover 10cm will be reduced from section area. The ρ will vary in the pile pit and it would be increased from bottom to top level of pile. Critical length is 2m from tip into up that steel mesh could be floated in fresh concrete. Equation 16 to 20 and Table 1 will explain the floating processing.

$$\rho = \frac{A_{SteelBars}}{A_{EffectiveConcrete}} \leq 0.02 \tag{16}$$

$$A_{SteelBars} = \rho \times A_{EffectiveConcrete} \quad \rightarrow \quad A_{SteelBars} = 108\left(cm^2\right)$$

$$A_{SteelMesh} = \pi D \times t \left(cm^2\right) \tag{17}$$

$$t = 1\left(cm\right) \Rightarrow \quad A_{SteelMesh} = \pi\underbrace{\left(120 - 2\times 10\right)}_{D\left(cm\right)} \times \underbrace{1cm}_{t} = 314\left(cm^2\right)$$

$$\rho' = \frac{A_{SteelMesh}}{A_{SteelBars}} = \frac{314}{108} \cong 300\% = 3 \tag{18}$$

$$F_{Bouncy} = \gamma_c \cdot \Delta H \times \left(\frac{314cm^2 + 108cm^2}{10;000}\right) - \left(1'010kg + 200kg\right)$$

$$F_{Bouncy} = 2400 \cdot \Delta H \times \left(0.0422cm^2\right) \geq 1'210kg$$

$$\left(F_{Bouncy}\right)_{t=1cm} = 101 \times \Delta H \geq 1'210\ (kg) \tag{19}$$
$$t = 2\ (cm)$$

$$\left(F_{Bouncy}\right)_{t=2cm} = 177 \times \Delta H \geq 1'210\ (kg) \tag{20}$$

Table 1: Bouncy Forces and Length of Concreting in the Pile (t=1, 2 cm)

ΔH	11	13	14	15
F_B (t=1cm)	-99	+103	+204	+305
F_B (t=2cm)	+737	+1'091	+1'268	+1'445

4. Conclusion

Steel bouncy in the cast-in-place piles could be prevented in the pile pit through circulation of liquid, cutting the spiral mesh at bottom to 1m above, reduce the ρ of steel bars from top to end and increase the slump of fresh concrete more than 25cm.

Aggregates can be made a temporary strip around the first spiral turn that will exert the concrete stresses into steel basket. This event is a random variable and may be solved by basket steel weight considerations and ρ of steel bars (Ulrich, 2004). Pile with length 12m will be floated in pit and it can be safe for pile length 25m with constant ρ. Critical length of floating is between 12m to 17m that weight of total steel will be less than the exerted load of fresh concrete operation.

5. References

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