# Pipeline Buoyancy Calculation

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$Type := $ "API 5l X65"

$D_{out} := 20\ \text{in} = 0.508\ \text{m}$

$t := 11.90\ \text{mm}$

$D_{in} := D_{out} - 2 \cdot (t) = 0.4842\ \text{m}$

$H := 1\ \text{m}$

$h_w := 1\ \text{m}$

$\gamma_{soil} := 1281\ \frac{\text{kg}}{\text{m}^3}$

$\gamma_{fluid} := 850\ \frac{\text{kg}}{\text{m}^3}$

$\gamma_{water} := 1000\ \frac{\text{kg}}{\text{m}^3}$

$\gamma_{pipe} := 7850\ \frac{\text{kg}}{\text{m}^3}$

$A_{pipe.steel} := \frac{\pi}{4} \cdot \left(D_{out}^{\ 2} - D_{in}^{\ 2}\right) = 18546.675\ \text{mm}^2$

$A_{pipe.inside} := \frac{\pi}{4} \cdot D_{in}^{\ 2} = 1.982\ \text{ft}^2$

$W_{pipe} := A_{pipe.steel} \cdot \gamma_{pipe} = 145.5914\ \frac{\text{kg}}{\text{m}}$

$W_{fluid} := A_{pipe.inside} \cdot \gamma_{fluid} = 156.5159\ \frac{\text{kg}}{\text{m}}$

$$P_v = \gamma C \qquad (3\text{-}1)$$

where:

$P_v$ = earth dead load pressure on the conduit

$\gamma$ = total dry unit weight of fill

$C$ = height of fill above top of pipe

For conditions where the pipe is located below the water table, the effect of soil grain buoyancy can be included in the earth load pressure using Equation 3-2.

$$P_v = \gamma_w h_w + R_w \gamma_d C \qquad (3\text{-}2)$$

where:

$P_v$ = earth dead load pressure on the conduit

$\gamma_d$ = dry unit weight of backfill

$C$ = height of fill above top of pipe

$h_w$ = height of water above pipe

$\gamma_w$ = unit weight of water

$R_w$ = water buoyancy factor = 1- 0.33($h_w$/$C$)

$P_v := \gamma_{water} \cdot h_w + \left(1 - (0.33) \cdot \left(\frac{1\ \text{m}}{1\ \text{m}}\right)\right) \cdot \gamma_{soil} \cdot 1\ \text{m} = 1858.27\ \frac{\text{kg}}{\text{m}^2}$

$W_{soil} := D_{out} \cdot \left(P_v - \gamma_{water} \cdot h_w\right) = 436.0012\ \frac{\text{kg}}{\text{m}}$

downforce scenarios

$$W_{p\_f} := W_{pipe} + W_{fluid} = 302.1073\ \frac{kg}{m}$$

$$W_{p\_s} := W_{pipe} + W_{soil} = 581.5926\ \frac{kg}{m}$$

$$W_{P\_F\_S} := W_{pipe} + W_{fluid} + W_{soil} = 738.1084\ \frac{kg}{m}$$

$$W_{up} := \frac{\pi}{4} \cdot D_{out}^{\ 2} \cdot \gamma_{water} = 202.683\ \frac{kg}{m}$$

worst-case downforce scenarios

$$\Gamma := \min\left(\begin{bmatrix} W_{p\_f} \\ W_{p\_s} \\ W_{P\_F\_S} \end{bmatrix}\right) = 302.1073\ \frac{kg}{m}$$

$$\begin{cases} \text{"Stable"} & \text{if } \Gamma \geq W_{up} \\ \text{"Unstable"} & \text{otherwise} \end{cases} = \text{"Stable"}$$