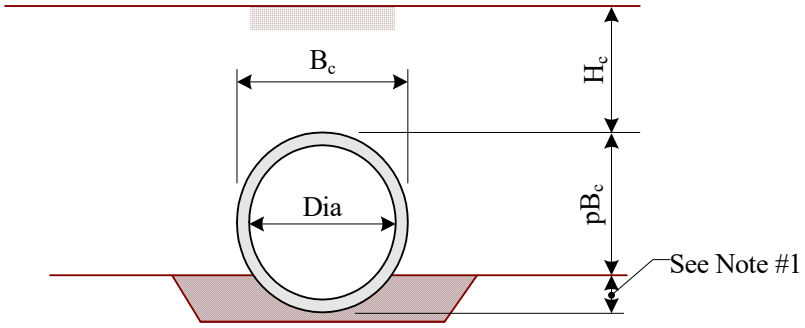
Project:
Subject:
Design By: **Checked By:**

References:

1. EM 1110-2-2902, Conduits, Culverts and Pipes, 31 October 1997 (CH1 31 March 98)
2. Concrete Pipe Design Manual, American Concrete Pipe Association, April 2007
3. Design Data 1, Highway Live Loads on concrete Pipe, American Concrete Pipe Association, July 2009
4. ASTM C76, Reinforced Concrete Culvert, Storm Drain, And Sewer Pipe, 2010
5. AWWA Manual M9, Third Edition, 2011



Given:

Pipe Inside Diameter: $Dia := 72 \cdot in$ Height of fill: $H_c := 8.54 \cdot ft$

Pipe wall thickness based on ASTM C76 (Wall A, B or C): $T_{wall} := 6 \cdot in$

Pipe outside diamater: $B_c := Dia + 2 \cdot T_{wall}$ $B_c = 7.000\,ft$

Saturated Unit Weight of soil: $\gamma := 133 \cdot pcf$

Hydraulic Factor: $H_f := 1.3$ *The pipe is designed per Chapter 3 of Reference #1.*

Specific weight of water: $\gamma_w := 62.4 \cdot pcf$

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Determination of Bedding Factor:

Note:

1. Typical COE guide specification for bedding requirements for RCP are as follows:

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe. When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded carefully in a ***soil foundation accurately shaped and rounded to conform to the lowest one-fourth of the outside portion of circular pipe*** *for the entire length of the pipe. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall be only of such length, depth, and width as required for properly making the particular type of joint.*

2. The requirements above correspond to Ordinary Bedding (Fig.3-2b of Ref. #1) or Class C Bedding (Fig. B-16 of Ref. #2) which have a projection ratio $\rho := 0.9$.

From Table 3-2 of Ref#1

$X_p := 0.840$ $X_a := .655$ Table 3-2 of Ref #1

$$B_f := \frac{1.431}{X_p - \frac{X_a}{3}} \qquad B_f = 2.302$$ EQ 3-1 of Ref # 1

Determination of Earth Load:

See reference #1, para 5-4, para. 3-7a.(2)

$$W_E := 1.5 \cdot B_c \cdot \left(H_c \cdot \gamma\right)$$

$$W_E = 11926 \cdot \frac{lbf}{LF}$$ Eq. 2-12 of Ref #1

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Determination of Live Load (HS 20-44) Pressure:

See reference #3, Table 3

Vehicle Traveling Perpendicular to the Pipe

$$P := \begin{cases} 16000 \cdot lbf & \text{if } H_c + 1.30B_c < 2.30 \cdot ft \\ 32000 \cdot lbf & \text{if } 2.30 \cdot ft - 1.30B_c \le H_c < 6.3 \cdot ft \\ 50000 \cdot lbf & \text{otherwise} \end{cases}$$

$P = 50000\ lbf$ <=== Critical Wheel Laod

Surface Contact Area: $a := 1.67ft$ $b := .83ft$

Spread load Area at the top side of Pipe

$$Spread_b := \begin{cases} (b + H_c) & \text{if } H_c + 1.30B_c < 2.30 \cdot ft \\ (b + H_c) & \text{if } 2.30 \cdot ft - 1.30B_c \le H_c < 6.3 \cdot ft \\ (b + 4ft + H_c) & \text{otherwise} \end{cases}$$

$Spread_b = 13.370\ ft$

$$Spread_a := \begin{cases} (a + H_c) & \text{if } H_c + 1.30B_c < 2.30 \cdot ft \\ (a + 4ft + H_c) & \text{if } 2.30 \cdot ft - 1.30B_c \le H_c < 6.3 \cdot ft \\ (a + 4ft + H_c) & \text{otherwise} \end{cases}$$

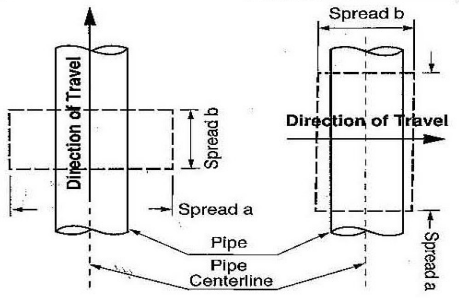
$Spread_a = 14.210\ ft$

Determination of Live Load (HS 20-44) Pressure Continued:

$A := Spread_a \cdot Spread_b$

$A = 189.988 \cdot ft^2$ <=== Critical Wheel Load Area

Figure 6 Spread Load Area Dimensions vs Direction of Truck



L = dimension of A parallel to the longitudinal axis of pipe, feet
For vehicles traveling perpendicular to the pipe, L = spread a
For vehicles traveling parallel to the pipe, L = spread b

S_L = outside horizontal span of pipe, D_o, or spread wheel load area, A, transverse to the longitudinal axis of pipe, whichever is less, feet

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Impact Factor:

See reference #3, Eqn 1

$$IM := \begin{cases} 0 & \text{if } H_c \geq 8\,ft \\ \dfrac{33(1.0\,ft - .125H_c)}{100\,ft} & \text{otherwise} \end{cases} \qquad IM = 0.000$$

Average Presssure intensity

See reference #3, Eqn 3

$$w := \frac{P\cdot(1 + IM)}{A} \qquad w = 263.175\cdot psf$$

Total Live Load

See reference #3, Eqn 4 & 5

Since the truck travels transverse to the pipe centerline:

$$L := Spread_a \qquad L = 14.210\,ft$$

$$S_L := \begin{cases} Spread_b & \text{if } Spread_b \leq B_c \\ B_c & \text{otherwise} \end{cases} \qquad S_L = 7.000\,ft$$

$$W_T := w\cdot L\cdot S_L \qquad W_T = 2.618 \times 10^4\,lbf$$

$$L_e := L + 1.75\left(\frac{3}{4}B_c\right) \qquad L_e = 23.397\,ft$$

$$W_L := \frac{W_T}{L_e} \qquad W_L = 1118.838\cdot\frac{lbf}{ft}$$

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Required D Load :

See reference #1, Pg. 3-6, Eqn 3-2

$$D_{0.01} := \frac{H_f \cdot (W_L + W_E)}{B_f \cdot Dia}$$

$$D_{0.01} = 1227.870 \cdot \frac{lbf}{LF \cdot ft}$$ USE