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Project: CONCRETE SLEEPER DESIGN (5kPa AND 10kPa SURCHARGE)	Page: 1
CONCRETE STRENGTH N40 GRADE CONCRETE	Ref: 7349
	Designed: AFC
Client: SUNSET SLEEPERS	Date: OCT 2018

NOTE: "d_o" AND "d" VALUES BASED ON THE FOLLOWING CLIENT ADVICE:

→ 80 SLEEPER $d = d_o = 39$
→ 100 SLEEPER $d = d_o = 59$

CONCRETE SLEEPER DESIGN

1.0 MAX BENDING MOMENT

1.1 200 x 80 THICK SLEEPER

CONCRETE STRENGTH = 40 MPa
REINFORCEMENT = 2-12mm BARS CENTRAL

$$M^* = \phi M_L = \phi A_{st} f_{sy} d \left[1 - \frac{0.6 A_{st} f_{sy}}{l_d f'_c}\right]$$

$$= 0.8 \times 226 \times 10^{-6} \times 500 \times 10^3 \times 39 \times 10^3 \left[1 - \frac{0.6 \times 226 \times 10^{-6} \times 500 \times 10^3}{200 \times 10^{-3} \times 39 \times 10^{-3} \times 40 \times 10^3}\right]$$

$$40\,MPa \leq 3.53 \left[1 - \frac{67.8}{312}\right] = \underline{2.76\,kN\text{-}m}$$

1.2 200 x 100 THICK SLEEPER

CONCRETE STRENGTH = 40MPa
REINFORCEMENT = 2-12mm BARS CENTRAL

$$M^* \leq 0.8 \times 226 \times 10^{-6} \times 500 \times 10^3 \times 59 \times 10^{-3} \left[1 - \frac{0.6 \times 226 \times 10^{-6} \times 500 \times 10^3}{200 \times 10^{-3} \times 39 \times 10^{-3} \times 40 \times 10^3}\right]$$

$$40\,kPa \leq 5.33 \left[1 - \frac{67.8}{475}\right] = \underline{4.57\,kN\text{-}m}$$

2.0 MAX SHEAR

2.1 200x 80 THICK SLEEPER

CONCRETE STRENGTH = 40 MPa
REINFORCEMENT = 2-12mm BARS CENTRAL

$$V^* \leq 0.5\,\phi\,V_{Lc}$$
$$\leq 0.5 \times 0.7 \times \beta_1 \beta_2 \beta_3 l_v d_o f_{cv} \left(\frac{A_{st}}{l_v d_o}\right)^{1/3}$$

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WHERE $\beta_1 = 1.1(1.6 - d_o/1000) \geq 1.1$

$= 1.1(1.6 - 39/1000) = 1.72 > 1.1$ ok!

$\beta_2 = 1$ $b_v = 200 \times 10^{-3}$ $f_{cv} = 3.42$

$\beta_3 = 1$ $d_o = 39 \times 10^{-3}$ $A_{st} = 226 \times 10^{-6}$

$$V^* \leq 0.5 \times 0.7 \times 1.72 \times 1 \times 1 \times 200 \times 10^{-3} \times 39 \times 10^{-3} \times 3.42 \times 10^3 \left(\frac{226 \times 10^{-6}}{0.2 \times 0.39}\right)^{1/3}$$

$\leq \underline{4.93 \text{ kN}}$

2.2 200 x 100 THICK SLEEPER

CONCRETE STRENGTH = 40 MPa
REINFORCEMENT = 2-12mm BARS CENTRAL

$V^* \leq 0.5 \phi V_{uc}$

$\beta_1 = 1.1(1.6 - 59/1000) = 1.695 > 1.1$ ok!

$\beta_2 = 1$ $b_v = 200 \times 10^{-3}$ $f_{cv} = 3.42$

$\beta_3 = 1$ $d_o = 59 \times 10^{-3}$ $A_{st} = 226 \times 10^{-6}$

$$\leq 0.5 \times 0.7 \times 1.695 \times 1 \times 1 \times 200 \times 10^{-3} \times 59 \times 10^{-3} \times 3.42 \times 10^3 \left(\frac{226 \times 10^{-6}}{0.2 \times 0.59}\right)^{1/3}$$

$\leq \underline{6.40 \text{ kN}}$

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3.0 MAX RETAINED HEIGHT

3.1 200 x 80 THICK x 1800 LONG SLEEPER

$M^* \leq 2.76$ kN-m , $V^* = 4.93$kN
ALLOWABLE LOAD AT BASE OF WALL

$$\Rightarrow M^* = \frac{wl^2}{8}\ ;\ w = \frac{8M}{l^2} = \frac{8 \times 2.76}{1.8^2} = 6.81 \text{ kN-m}$$

$$\text{OR} \Rightarrow V^* = \frac{wL}{2}\ ;\ w = \frac{2V}{l} = \frac{2 \times 4.93}{1.8} = 5.48 \text{ kN-m}$$

∴ SHEAR DESIGN CASE GOVERNS

$$\text{PRESSURE AT BASE} = \frac{5.48 \text{ kN-m}}{0.2 \text{ m}} = 27.4 \text{ kPa}$$

MAX RETAINED HEIGHT 5kPa SURCHARGE ⇒

$$27.4 = 1.5 \times 5.0\text{kPa} \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$$
$$24.775 = 8.58H$$
$$H = 2.888\text{m} = \underline{2888\text{mm}}$$

MAX RETAINED HEIGHT 10kPa SURCHARGE

$$27.4 = 1.5 \times 10\text{kPa} \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$$
$$22.15 = 8.58H$$
$$H = 2.582\text{m} = \underline{2582\text{mm}}$$

3.2 200 x 80 THICK x 2000 LONG SLEEPER

ALLOWABLE LOAD AT BASE OF WALL

$$\Rightarrow M^* = \frac{wl^2}{8}\ ;\ w = \frac{8M}{l^2} = \frac{8 \times 2.76}{2^2} = 5.52 \text{ kN-m}$$

$$\text{OR} \Rightarrow V^* = \frac{wL}{2}\ ;\ w = \frac{2V}{L} = \frac{2 \times 4.93}{2} = 4.93 \text{ kN-m}$$

∴ SHEAR DESIGN CASE GOVERNS

$$\text{PRESSURE AT BASE} = \frac{4.93}{0.2} = 24.65 \text{ kPa}$$

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MAX RETAINED HEIGHT 5kPa SURCHARGE ⇒

$24.65 = 1.5 \times 5.0kPa \times 0.35 + 1.25 \times 19.62 \times 0.35H$
$22.025 = 8.58H$
$H = 2.567m = \underline{2567mm}$

MAX RETAINED HEIGHT 10kPa SURCHARGE ⇒

$24.65 = 1.5 \times 10kPa \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$
$19.40 = 8.58H$
$H = 2.261m = \underline{2261mm}$

3.3 200x80 THICK x 2400 LONG SLEEPER

ALLOWABLE LOAD AT BASE OF WALL

$\Rightarrow M^* = \frac{Wl^2}{8}$; $W = \frac{8M}{l^2} = \frac{8 \times 2.76}{2.4^2} = 3.833$ kN-m

OR $\Rightarrow V^* = \frac{WL}{2}$; $W = \frac{2V}{L} = \frac{2 \times 4.93}{2.4} = 4.108$ kN-m

∴ BENDING MOMENT DESIGN CASE GOVERNS

PRESSURE AT BASE = $\frac{3.833}{0.2} = 19.165$ kPa

MAX RETAINED HEIGHT 5kPa SURCHARGE ⇒

$19.165 = 1.5 \times 5.0kPa \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$
$16.54 = 8.58H$
$H = 1.928m = \underline{1928mm}$

MAX RETAINED HEIGHT 10kPa SURCHARGE ⇒

$19.165 = 1.5 \times 10kPa \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$
$13.915 = 8.58H$
$H = 1.622m = \underline{1622mm}$

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3.4 200 x 100 THICK x 1800 LONG SLEEPER

$M^* \leq 4.57$ kN-m, $V^* \leq 6.40$ kN

ALLOWABLE LOAD AT BASE OF WALL

$$\Rightarrow M^* = \frac{wl^2}{8}; \quad W = \frac{8M}{l^2} = \frac{8 \times 4.57}{1.8^2} = 11.284 \text{ kN-m}$$

$$\text{OR} \Rightarrow V^* = \frac{WL}{2}; \quad W = \frac{2V}{L} = \frac{2 \times 6.40}{1.8} = 7.11 \text{ kN-m}$$

∴ SHEAR DESIGN CASE GOVERNS

$$\text{PRESSURE AT BASE} = \frac{7.11}{0.2} = 35.55 \text{ kPa}$$

MAX RETAINED HEIGHT 5kPa SURCHARGE ⇒

$$35.55 = 1.5 \times 5.0\text{kPa} \times 0.35 + 1.25 \times 19.62 \times 0.35H$$
$$32.925 = 8.58H$$
$$H = 3.837\text{m} = \underline{3837 \text{ mm}}$$

MAX RETAINED HEIGHT 10kPa SURCHARGE ⇒

$$35.55 = 1.5 \times 10\text{kPa} \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$$
$$30.30 = 8.58H$$
$$H = 3.531\text{m} = \underline{3531 \text{ mm}}$$

3.5 200x 100 THICK x 2000 LONG SLEEPER

ALLOWABLE LOAD AT BASE OF WALL

$$\Rightarrow M^* = \frac{wl^2}{8}; \quad W = \frac{8M}{l^2} = \frac{8 \times 4.57}{2^2} = 9.14 \text{ kN-m}$$

$$\text{OR} \Rightarrow V^* = \frac{WL}{2}; \quad V = \frac{2V}{L} = \frac{2 \times 6.40}{2} = 6.40 \text{ kN-m}$$

∴ SHEAR DESIGN CASE GOVERNS

$$\text{PRESSURE AT BASE} = \frac{6.40}{0.2} = 32 \text{ kPa}.$$

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MAX RETAINED HEIGHT 5kPa SURCHARGE ⇒

$32.00 = 1.5 \times 5.0kPa \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$
$29.375 = 8.58H$
$H = 3.424m = \underline{3424mm}$

MAX RETAINED HEIGHT 10kPa SURCHARGE ⇒

$32.00 = 1.5 \times 10kPa \times 0.35 + 1.25 \times 19.62 \times 0.35 \times H$
$26.75 = 8.58H$
$H = 3.118m = \underline{3118mm}$

3.6 200 x 100 THICK x 2400 LONG SLEEPER

ALLOWABLE LOAD AT BASE OF WALL

$\Rightarrow M^* = \frac{wl^2}{8}$; $W = \frac{8M}{l^2} = \frac{8 \times 4.57}{2.4^2} = 6.372$ kN-m

OR $\Rightarrow V^* = \frac{WL}{2}$; $W = \frac{2V}{L} = \frac{2 \times 6.40}{2.4} = 6.40$ kN-m

∴ BENDING MOMENT DESIGN CASE GOVERNS

PRESSURE AT BASE $= \frac{6.372}{0.2} = 31.86$ kPa

MAX RETAINED HEIGHT 5kPa SURCHARGE ⇒

$31.86 = 1.5 \times 5.0kPa \times 0.35 + 1.25 \times 19.62 \cdot 0.35 H$
$29.235 = 8.58H$
$H = 3.407m = \underline{3407mm}$

MAX RETAINED HEIGHT 10kPa SURCHARGE ⇒

$31.86 = 1.5 \times 10kPa \times 0.35 + 1.25 \times 19.62 \cdot 0.35 \times H$
$26.61 = 8.58H$
$H = 3.101m = \underline{3101mm}$