

Hudson Environ

Civil and Structural Engineering

ENGINEERING CALCULATIONS

PRECAST CONCRETE  
RETAINING WALL SLEEPERS

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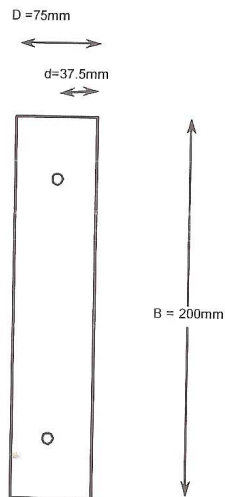
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### Concrete Retaining Wall Sleepers - 75mm x 200mm for Ken Harrington & Associates

Concrete retaining wall elements comprise precast concrete planks supported between the flanges of Steel joist and channel sections. These calculations demonstrate the adequacy of the concrete planks, or sleepers. Loadings are derived from AS 4678 Earth retaining structures. Analysis follows the requirements of AS 3600 Concrete structures Code.

#### Moment Capacity

Nominal Depth of Section	$d := 37.5\text{mm}$	$\phi := 0.8$
Nominal Width of Section	$b := 200\text{mm}$	
Main Reinforcement 2-N8 bars	$\text{diam} := 8\text{mm}$	
	$A_{st} := 2 \cdot \pi \cdot \frac{\text{diam}^2}{4}$	$A_{st} = 100.53\text{mm}^2$
Concrete Strength	$f_c := 25\text{MPa}$	
Steel, Min Yield	$f_{sy} := 400\text{MPa}$	$\gamma := 0.85$



$$p := \frac{A_{st}}{b \cdot d} \quad p = 0.01$$

$$k_u := \frac{A_{st} \cdot f_{sy}}{0.85 \cdot f_c \cdot \gamma \cdot d \cdot b} \quad k_u = 0.3$$

$$p_{max} := \frac{0.4 \cdot 0.85 \cdot \gamma \cdot f_c}{f_{sy}} \quad p_{max} = 0.02$$

$$SI := p \cdot \frac{f_{sy}}{f_c} \quad SI = 0.21$$

$$\phi M_{ub} := \phi \cdot p \cdot f_{sy} \cdot (1 - 0.6 \cdot SI) \cdot b \cdot d^2$$

$$\phi M_{ub} = 1.05\text{ kNm} \quad \text{Capacity of section due to lateral load.}$$

Figure 1. Notional Model for Analysis

#### Shear Strength

$b = 200\text{ mm}$
$d = 37.5\text{ mm}$
$A_{st} = 100.53\text{ mm}^2$

AS 3600 section 8.2.7.1

$$\beta := 1.1 \cdot 10^4 \text{ N}^{\frac{2}{3}} \cdot \text{m}^{\frac{-4}{3}}$$

$$\phi V_{uc} := \phi \cdot \beta \cdot b \cdot d \cdot \left( \frac{A_{st}}{b \cdot d} \cdot f_c \right)^{\frac{1}{3}}$$

$$\phi V_{uc} = 4.58\text{ kN}$$

### Concrete Retaining Wall Sleepers for Ken Harrington & Associates

Load factors - from retaining wall design  
factor on loads tending to cause instability = 1.0  
factor on loads tending to resist instability = 0.8

#### Design loads

Density of reinforced concrete,  $\gamma_c := 25 \frac{\text{kN}}{\text{m}^3}$

Density of soil,  $\gamma_s := 18 \frac{\text{kN}}{\text{m}^3}$

Surcharge on backfill (allow for fill on high side)  $H_f := 0.3\text{m}$

#### Capacity reduction factors

Partial factor for cohesion = 0.7

Reinforced concrete base (bending) = 0.8

Reinforced concrete base (shear) = 0.7

Bearing and sliding on foundation = 0.8

Steel Post supporting concrete = 0.9

#### Soil properties

Nominal internal friction angle.  $\phi_n := 38\text{deg}$

Design internal friction angle.  $\phi_w := 32\text{deg}$

Nominal drained cohesion.  $c_n := 0\text{kPa}$

Design drained cohesion.  $c_u := 0\text{kPa}$

Slope of backfill.  $\beta_w := 0\text{deg}$

Nett height of wall  $H_n := 1.5\text{m}$

Design height  $H_w := H_n + H_f$

$$\delta_w := \frac{2}{3} \cdot \phi$$

$$\delta = 21.33 \text{ deg}$$

$$H = 1.8 \text{ m}$$

#### Active pressure coefficient.

$$K_a := \frac{\cos(\phi)^2}{\cos(\delta) \cdot \left[ 1 + \sqrt{\frac{(\sin(\phi - \beta) \cdot \sin(\phi + \delta))}{\cos(\beta) \cdot \cos(\delta)}} \right]^2}$$

$$K_a = 0.275$$

#### Peak pressure on the retaining wall

Triangular pressure distribution

$$P_{\max} := K_a \cdot (\gamma_s \cdot H)$$

$$P_{\max} = 8.91 \text{ kPa}$$

**Concrete Sleepers to span 2.0m**  
**Bending moment on 200mm width of sleeper -**

Span	$L_1 := 2.0\text{m}$	
	$\text{Load\_width} := 0.2\text{m}$	
Design load	$w := P_{\text{max}} \cdot \text{Load\_width}$	$w = 1.78 \frac{\text{kN}}{\text{m}}$
Design Moment	$M^* := \frac{w \cdot L_1^2}{8}$	$M^* = 0.89 \text{kNm}$
$\phi M_{ub} > M^*$ ok	$1.05 > 0.89$	

Limit effective height for 75mm planks to 1.5m

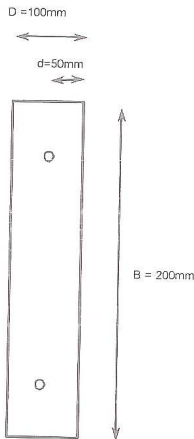
$$\text{kN} \equiv 1000\text{N} \quad \text{MPa} \equiv \frac{\text{N}}{\text{mm}^2} \quad \text{kPa} \equiv \frac{\text{kN}}{\text{m}^2} \quad \text{kNm} \equiv \text{kN} \cdot \text{m}$$

### Concrete Retaining Wall Sleepers - 100mm x 200mm for Ken Harrington & Associates

Concrete retaining wall elements comprise precast concrete planks supported between the flanges of Steel joist and channel sections. These calculations demonstrate the adequacy of the concrete planks, or sleepers. Loadings are derived from AS 4678 Earth retaining structures. Analysis follows the requirements of AS 3600 Concrete structures Code.

#### Moment Capacity

Nominal Depth of Section	$d := 50\text{mm}$	$\phi := 0.8$
Nominal Width of Section	$b := 200\text{mm}$	
Main Reinforcement 2-N8 bars	$\text{diam} := 10\text{mm}$	
	$A_{st} := 2 \cdot \pi \cdot \frac{\text{diam}^2}{4}$	$A_{st} = 157.08 \text{ mm}^2$
Concrete Strength	$f_c := 25\text{MPa}$	
Steel, Min Yield	$f_{sy} := 400\text{MPa}$	$\gamma := 0.85$



$$p := \frac{A_{st}}{b \cdot d} \quad p = 0.02$$

$$k_u := \frac{A_{st} \cdot f_{sy}}{0.85 \cdot f_c \cdot \gamma \cdot d \cdot b} \quad k_u = 0.35$$

$$p_{max} := \frac{0.4 \cdot 0.85 \cdot \gamma \cdot f_c}{f_{sy}} \quad p_{max} = 0.02$$

$$SI := p \cdot \frac{f_{sy}}{f_c} \quad SI = 0.25$$

$$\phi M_{ub} := \phi \cdot p \cdot f_{sy} \cdot (1 - 0.6 \cdot SI) \cdot b \cdot d^2$$

$$\phi M_{ub} = 2.13 \text{ kNm} \quad \text{Capacity of section due to lateral load.}$$

Figure 1. Notional Model for Analysis

#### Shear Strength

$$b = 200 \text{ mm}$$

$$d = 50 \text{ mm}$$

$$A_{st} = 157.08 \text{ mm}^2$$

AS 3600 section 8.2.7.1

$$\beta := 1.1 \cdot 10^4 \text{ N}^{\frac{2}{3}} \cdot \text{m}^{\frac{-4}{3}}$$

$$\phi V_{uc} := \phi \cdot \beta \cdot b \cdot d \cdot \left( \frac{A_{st}}{b \cdot d} \cdot f_c \right)^{\frac{1}{3}}$$

$$\phi V_{uc} = 6.44 \text{ kN}$$

### Concrete Retaining Wall Sleepers for Ken Harrington & Associates

Load factors - from retaining wall design  
factor on loads tending to cause instability = 1.0  
factor on loads tending to resist instability = 0.8

#### Design loads

Density of reinforced concrete,  $\gamma_c := 25 \frac{\text{kN}}{\text{m}^3}$

Density of soil,  $\gamma_s := 18 \frac{\text{kN}}{\text{m}^3}$

Surcharge on backfill (allow for fill on high side)  $H_f := 0.3\text{m}$

#### Capacity reduction factors

Partial factor for cohesion = 0.7

Reinforced concrete base (bending) = 0.8

Reinforced concrete base (shear) = 0.7

Bearing and sliding on foundation = 0.8

Steel Post supporting concrete = 0.9

#### Soil properties

Nominal internal friction angle.  $\phi_n := 38\text{deg}$

Design internal friction angle.  $\phi_{\text{des}} := 32\text{deg}$   $\delta := \frac{2}{3} \cdot \phi$

Nominal drained cohesion.  $c_n := 0\text{kPa}$

Design drained cohesion.  $c_{\text{des}} := 0\text{kPa}$   $\delta = 21.33\text{deg}$

Slope of backfill.  $\beta := 0\text{deg}$

Nett height of wall  $H_n := 4.0\text{m}$

Design height  $H_{\text{des}} := H_n + H_f$   $H = 4.3\text{m}$

#### Active pressure coefficient.

$$K_a := \frac{\cos(\phi)^2}{\cos(\delta) \cdot \left[ 1 + \sqrt{\frac{(\sin(\phi - \beta) \cdot \sin(\phi + \delta))}{\cos(\beta) \cdot \cos(\delta)}} \right]^2} \quad K_a = 0.275$$

#### Peak pressure on the retaining wall

Triangular pressure distribution

$P_{\text{max}} := K_a \cdot (\gamma_s \cdot H)$   $P_{\text{max}} = 21.29\text{kPa}$

Concrete Sleepers to span 2.0m  
Bending moment on 200mm width of sleeper -

Span	$L_1 := 2.0\text{m}$	
	Load_width := 0.2m	
Design load	$w := P_{\text{max}} \cdot \text{Load\_width}$	$w = 4.26 \frac{\text{kN}}{\text{m}}$
Design Moment	$M^* := \frac{w \cdot L_1^2}{8}$	$M^* = 2.13 \text{ kNm}$
$\phi M_{ub} > M^*$ ok	$2.13 > 2.13$	
Shear force	$V^* := \frac{w \cdot L_1}{2}$	$V^* = 4.26 \text{ kN}$
$\phi V_u > V^*$	$6.44 > 4.26$	

Limit effective height for 100mm planks to 4m

$$\text{kN} \equiv 1000\text{N} \quad \text{MPa} \equiv \frac{\text{N}}{\text{mm}^2} \quad \text{kPa} \equiv \frac{\text{kN}}{\text{m}^2} \quad \text{kNm} \equiv \text{kN} \cdot \text{m}$$