

CALCULATION		JOB No:	1646-01
	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF	PREPARED by	MH
		CHECKED by	TS
	TITLE: 2.4M HIGH HOARDING TO GROUND	REVISION	C0
CLIENT: SAFEFENCE		DATE:	24.04.2020

1. Project Description:

Calculations for 2.40m high hoarding secured to the ground.
All showed on DWG 1646-01-0.

This structure has been designed in accordance with:

- BS EN 1991-1-4:2005 - Wind Actions & TG20-13 Wind Guidance
- BS 5975:2019 - Code of practice for temp. works procedures and the permissible stress design of falsework
- TWf 2012:01 HOARDINGS: A guide to good practice

2. Structure geometry and loadings:

The minimum notional horizontal load applied to hoarding is:

$$H_z := 0.50 \frac{\text{kN}}{\text{m}} \quad h_z := 1.2\text{m} \quad \text{above the base.}$$

Hoarding dimensions:

$$\text{hoarding length: } l := 250\text{m}$$

$$\text{total length: } b := l = 250\text{m}$$

$$\text{bay width: } d := 20\text{m}$$

$$\text{hoarding height: } h := 2.40\text{m}$$

Site location data:

$$\text{altitude of the site: } A_1 := 61\text{m}$$

$$\text{distance to shoreline: } \text{dist}_{\text{shore}} := 70\text{km}$$

$$\text{distance inside town terrain: } \text{dist}_{\text{town}} := 0.5\text{km}$$

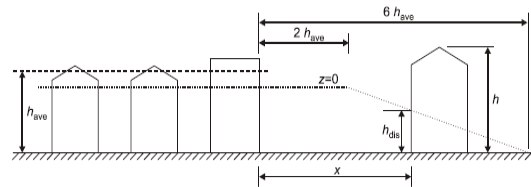
CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF	PREPARED by	MH
	TITLE: 2.4M HIGH HOARDING TO GROUND	CHECKED by	TS
	CLIENT: SAFEFENCE	REVISION	C0
		DATE:	24.04.2020

Displacement height:

$$h_{ave} := 0\text{m}$$

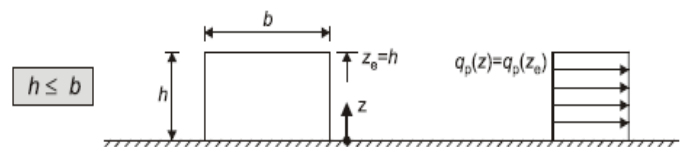
$$x := 0\text{m}$$

$$h_{dis} = 0\text{m}$$



Reference height for Wind Calculation:

$$h = 2.4\text{m} < b = 250\text{m}$$



reference height: $z_e := h = 2.4\text{m}$

Fundamental value of basic wind velocity:

fundamental value of basic wind
velocity before correction:

$$v_{b.m} := 22 \frac{\text{m}}{\text{s}} \quad (\text{Figure NA.1})$$

altitude factor: $c_{alt} = 1.061$

$$v_{b.0} := v_{b.m} \cdot c_{alt} = 23.342 \frac{\text{m}}{\text{s}}$$

CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF	PREPARED by	MH
		CHECKED by	TS
	TITLE: 2.4M HIGH HOARDING TO GROUND	REVISION	C0
	CLIENT: SAFEFENCE	DATE:	24.04.2020

The basic wind velocity:

probability factor: $c_{\text{prob}} := 0.83$ (for two-year return time)

directional factor: $c_{\text{dir}} := 1.0$

season factor: $c_{\text{season}} := 1.0$

$$v_b := c_{\text{prob}} \cdot c_{\text{dir}} \cdot c_{\text{season}} \cdot v_{b,0} = 19.374 \frac{\text{m}}{\text{s}}$$

Basic velocity pressure: $\rho := 1.226 \frac{\text{kg}}{\text{m}^3}$ air density (NA.2.18):

$$q_{bv} := \frac{1}{2} \cdot \rho \cdot v_b^2 = 0.23 \cdot \text{kPa}$$

exposure factor: $c_e := 1.55$ (Figure NA.7)

exposure factor
for town terrain: $c_{e,T} := 0.74$ (Figure NA.8)

FULL WIND $q_p := c_e \cdot c_{e,T} \cdot q_{bv} = 0.264 \cdot \text{kPa}$

WORKING WIND $q_{p,\text{work}} := 0.2 \text{kPa}$

CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF		PREPARED by MH
	TITLE: 2.4M HIGH HOARDING TO GROUND		CHECKED by TS
	CLIENT: SAFEFENCE		REVISION C0
			DATE: 24.04.2020

Wind pressure on surfaces - free-standing wall:

solidity ratio: $sr := 1$

return corners: YES

length to height ratio: $\frac{l}{h} = 104.167$

Table 7.9 — Recommended pressure coefficients $c_{p,net}$ for free-standing walls and parapets

Solidity	Zone	A	B	C	D
$\varphi = 1$	Without return corners	$l/h \leq 3$	2,3	1,4	1,2
		$l/h = 5$	2,9	1,8	1,4
		$l/h \geq 10$	3,4	2,1	1,7
	with return corners of length $\geq h$ ^a	2,1	1,8	1,4	1,2
$\varphi = 0,8$		1,2	1,2	1,2	1,2

^a Linear interpolation may be used for return corner lengths between 0,0 and h

Zone A:

$$c_{pe.net.A} = 2.1$$

$$W_A := q_p \cdot c_{pe.net.A} = 0.554 \cdot \text{kPa}$$

$$W_{A.w} := q_{p.work} \cdot c_{pe.net.A} = 0.42 \cdot \text{kPa}$$

Zone B:

$$c_{pe.net.B} = 1.8 \quad (\text{from table 7.9})$$

$$W_B := q_p \cdot c_{pe.net.B} = 0.475 \cdot \text{kPa}$$

$$W_{B.w} := q_{p.work} \cdot c_{pe.net.B} = 0.36 \cdot \text{kPa}$$

Zone C:

$$c_{pe.net.C} = 1.4 \quad (\text{from table 7.9})$$

$$W_C := q_p \cdot c_{pe.net.C} = 0.369 \cdot \text{kPa}$$

$$W_{C.w} := q_{p.work} \cdot c_{pe.net.C} = 0.28 \cdot \text{kPa}$$

Zone D:

$$c_{pe.net.D} = 1.2 \quad (\text{from table 7.9})$$

$$W_D := q_p \cdot c_{pe.net.D} = 0.317 \cdot \text{kPa}$$

$$W_{D.w} := q_{p.work} \cdot c_{pe.net.D} = 0.24 \cdot \text{kPa}$$

Zone D_{FREE}:

$$c_{pe.net.Dfe} := 2.1 \quad (\text{from table 7.9})$$

$$W_{D.fe} := q_p \cdot c_{pe.net.Dfe} = 0.554 \cdot \text{kPa}$$

$$W_{Dfe.w} := q_{p.work} \cdot c_{pe.net.Dfe} = 0.42 \cdot \text{kPa}$$

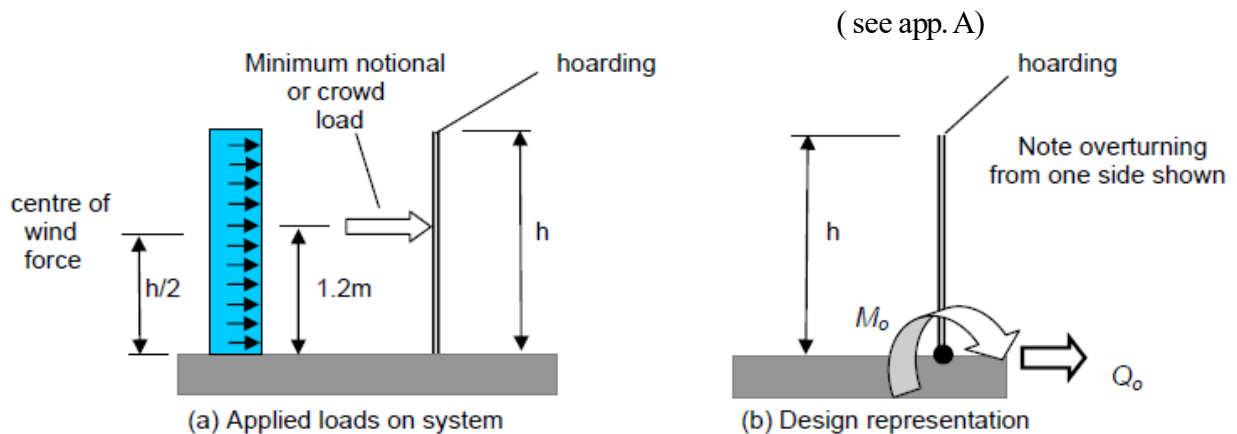
CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF		PREPARED by MH
	TITLE: 2.4M HIGH HOARDING TO GROUND		CHECKED by TS
	CLIENT: SAFEFENCE		REVISION C0
			DATE: 24.04.2020

3. Hoarding elements design:

Permissible Bending moment and Shear force

Post used: 75x150mm C24 timber

$$M_{Rd1} := 3.187 \text{ kNm} \quad Q_{Rd1} := 12.58 \text{ kN}$$



Load cases: L1: Full Wind, LC2: Working Wind+ Lateral Load

Zone B:

Overturning moment about base per m run of hoarding:

$$M_B := \max \left[\left(W_B \cdot h \right) \cdot \frac{h}{2}, \left(W_{B.w} \cdot h \right) \cdot \frac{h}{2} + H_Z \cdot h_Z \right] = 1.637 \cdot \frac{\text{kNm}}{\text{m}}$$

Shear force in base per m run of hoarding:

$$Q_B := \max \left(W_B \cdot h, W_{B.w} \cdot h + H_Z \right) = 1.364 \cdot \frac{\text{kN}}{\text{m}}$$

Max. post CRS:

$$CRS_B := \min \left(\frac{M_{Rd1}}{M_B}, \frac{Q_{Rd1}}{Q_B} \right) = 1.947 \text{ m} \quad \text{CRS}_B := 1.6 \text{ m}$$

no. of bays: n_B = 3

Zone C:

Overturning moment about base per m run of hoarding:

$$M_C := \max \left[\left(W_C \cdot h \right) \cdot \frac{h}{2}, \left(W_{C.w} \cdot h \right) \cdot \frac{h}{2} + H_Z \cdot h_Z \right] = 1.406 \cdot \frac{\text{kNm}}{\text{m}}$$

Shear force in base per m run of hoarding:

$$Q_C := \max \left(W_C \cdot h, W_{C.w} \cdot h + H_Z \right) = 1.172 \cdot \frac{\text{kN}}{\text{m}}$$

Max. post CRS:

$$CRS_C := \min \left(\frac{M_{Rd1}}{M_C}, \frac{Q_{Rd1}}{Q_C} \right) = 2.266 \text{ m} \quad \text{CRS}_C := 1.8 \text{ m}$$

no. of bays: n_C = 3

Zone D:

Overturning moment about base per m run of hoarding:

$$M_D := \max \left[\left(W_D \cdot h \right) \cdot \frac{h}{2}, \left(W_{D.w} \cdot h \right) \cdot \frac{h}{2} + H_Z \cdot h_Z \right] = 1.291 \cdot \frac{\text{kNm}}{\text{m}}$$

Shear force in base per m run of hoarding:

$$Q_D := \max \left(W_D \cdot h, W_{D.w} \cdot h + H_Z \right) = 1.076 \cdot \frac{\text{kN}}{\text{m}}$$

Max. post CRS:

$$CRS_D := \min \left(\frac{M_{Rd1}}{M_D}, \frac{Q_{Rd1}}{Q_D} \right) = 2.468 \text{ m} \quad \text{CRS}_D := 2.4 \text{ m}$$

no. of bays: remainder

CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF		PREPARED by MH
	TITLE: 2.4M HIGH HOARDING TO GROUND		CHECKED by TS
	CLIENT: SAFEFENCE		REVISION C0
			DATE: 24.04.2020

Zone D_{FREE END}:

Overturning moment about base per m run of hoarding:

$$M_{D.fe} := \max \left[(W_{D.fe} \cdot h) \cdot \frac{h}{2}, (W_{Dfe.w} \cdot h) \cdot \frac{h}{2} + H_z \cdot h_z \right] = 1.81 \cdot \frac{\text{kNm}}{\text{m}}$$

Shear force in base
per m run of hoarding:

$$Q_{D.fe} := \max (W_{D.fe} \cdot h, W_{Dfe.w} \cdot h + H_z) = 1.508 \cdot \frac{\text{kN}}{\text{m}}$$

Max. possible post CRS:

$$CRS_{D.fe} := \min \left(\frac{M_{Rd1}}{M_{D.fe}}, \frac{Q_{Rd1}}{Q_{D.fe}} \right) = 1.761 \text{ m}$$

$$CRS_{D.fe} := 1.5 \text{ m}$$

no. of bays: $n_{Dfe} = 7$

4. Horizontal rails design:

Permissible Bending moment and Shear force

Rails used: 100x50mm C24 timber beam

$$M_{Rd2} := 0.668 \text{ kNm} \quad Q_{Rd2} := 6.7 \text{ kN}$$

No. of rails used: $n := 3$

(see app. A)

$$\text{Calculated rails centres:} \quad CRS := \frac{h}{n-1} = 1.2 \text{ m}$$

The design assumption for worst case for one central rail is either full wind or working wind with full min. notional horizontal load applied to a single rail.

Max. linear loads on a single rail in different wind zones:

$$q_{Br} := \max (W_B \cdot CRS, W_{B.w} \cdot CRS + H_z) = 0.932 \cdot \frac{\text{kN}}{\text{m}}$$

$$q_{Cr} := \max (W_C \cdot CRS, W_{C.w} \cdot CRS + H_z) = 0.836 \cdot \frac{\text{kN}}{\text{m}}$$

$$q_{Dr} := \max (W_D \cdot CRS, W_{D.w} \cdot CRS + H_z) = 0.788 \cdot \frac{\text{kN}}{\text{m}}$$

$$q_{Dfer} := \max (W_{D.fe} \cdot CRS, W_{Dfe.w} \cdot CRS + H_z) = 1.004 \cdot \frac{\text{kN}}{\text{m}}$$

Extreme bending moment values for different wind zones:

$$M_{Br} := 0.125 \cdot q_{Br} \cdot CRS^2 = 0.298 \cdot \text{kNm}$$

$$M_{Cr} := 0.125 \cdot q_{Cr} \cdot CRS^2 = 0.339 \cdot \text{kNm}$$

CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF	PREPARED by	MH
	TITLE: 2.4M HIGH HOARDING TO GROUND	CHECKED by	TS
	CLIENT: SAFEFENCE	REVISION	C0
		DATE:	24.04.2020

$$M_{Dr} := 0.125 \cdot q_{Dr} \cdot CRS_D^2 = 0.567 \cdot \text{kNm}$$

Moment of resistance:

$$M_{Rd2} = 0.668 \cdot \text{kNm}$$

$$M_{Dfer} := 0.125 \cdot q_{Dfer} \cdot CRS_{D.fe}^2 = 0.282 \cdot \text{kNm}$$

hence = "PASS"

Extreme shear force values for different wind zones:

$$Q_{Br} := 0.625 \cdot q_{Br} \cdot CRS_B = 0.932 \text{ kN}$$

$$Q_{Cr} := 0.625 \cdot q_{Cr} \cdot CRS_C = 0.94 \text{ kN}$$

Allowable shear force:

$$Q_{Dr} := 0.625 \cdot q_{Dr} \cdot CRS_D = 1.182 \text{ kN}$$

$$Q_{Rd2} = 6.7 \text{ kN}$$

$$Q_{Dfer} := 0.625 \cdot q_{Dfer} \cdot CRS_{D.fe} = 0.941 \text{ kN}$$

hence = "PASS"

5. Face material design:

Permissible Bending moment and Shear force

Cover material used: 18mm FSC Grade

$$M_{Rd2} := 0.456 \frac{\text{kNm}}{\text{m}} \quad Q_{Rd2} := 6.34 \frac{\text{kN}}{\text{m}}$$

$$Q_{fply} := \max \left(0.5 \cdot 1.5 \frac{\text{kN}}{\text{m}^2} \cdot CRS, 0.5 W_{B.w} \cdot CRS + 0.5 \cdot H_Z \right) = 0.9 \cdot \frac{\text{kN}}{\text{m}}$$

$$M_{fply} := \max \left(0.125 \cdot 1.5 \frac{\text{kN}}{\text{m}^2} \cdot CRS^2, 0.125 W_{B.w} \cdot CRS^2 + 0.25 \cdot H_Z \cdot CRS \right) = 0.27 \cdot \frac{\text{kNm}}{\text{m}}$$

hence = "PASS"

Design for worst case loading of either panel robustness loading of 1.5 kN/m² or the effect of the min. notional horizontal load mid-way between rail, face material simply supported.

CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF	PREPARED by	MH
	TITLE: 2.4M HIGH HOARDING TO GROUND	CHECKED by	TS
	CLIENT: SAFEFENCE	REVISION	C0
		DATE:	24.04.2020

6. Connection of ply to rails:

For connection design wind in zone A should be considered.

Max. linear load on a single rail in wind zone A:

$$q_A := \max(W_A \cdot CRS, W_{A.w} \cdot CRS + H_z) = 1.004 \cdot \frac{\text{kN}}{\text{m}}$$

Basic withdrawal load per mm of penetration:

$$crs_s := 250\text{mm}$$

$$F_{\text{ww}} := 13.5 \frac{\text{N}}{\text{mm}}$$

Design factors: $K_{52} := 1.25$ (very short term loading) $K_{53} := 0.7$ (Class 3)

Point side penetration: $e_s := 50\text{mm} - 18\text{mm} = 32\text{mm}$

Permissible load per metre: $q_{Rd} := \frac{e_s \cdot F_{\text{ww}} \cdot K_{52} \cdot K_{53}}{crs_s} = 1.512 \cdot \frac{\text{kN}}{\text{m}} > q_A = 1.004 \cdot \frac{\text{kN}}{\text{m}}$
hence = "PASS"

7. Connection of rails to post:

$$CRS_A := CRS_B = 1.6\text{m}$$

Max. point load on a single post in wind zone A:

$$P_p := \max(W_A \cdot CRS, W_{A.w} \cdot CRS + H_z) \frac{CRS_A}{2} = 0.803 \cdot \text{kN}$$

Basic withdrawal load per mm of penetration:

Assumed no. of screws: $N_s := 1$ $F_{\text{ww}} := 22.1 \frac{\text{N}}{\text{mm}}$

Design factors: $K_{52} := 1.25$ (very short term loading) $K_{53} := 0.7$ (Class 3)

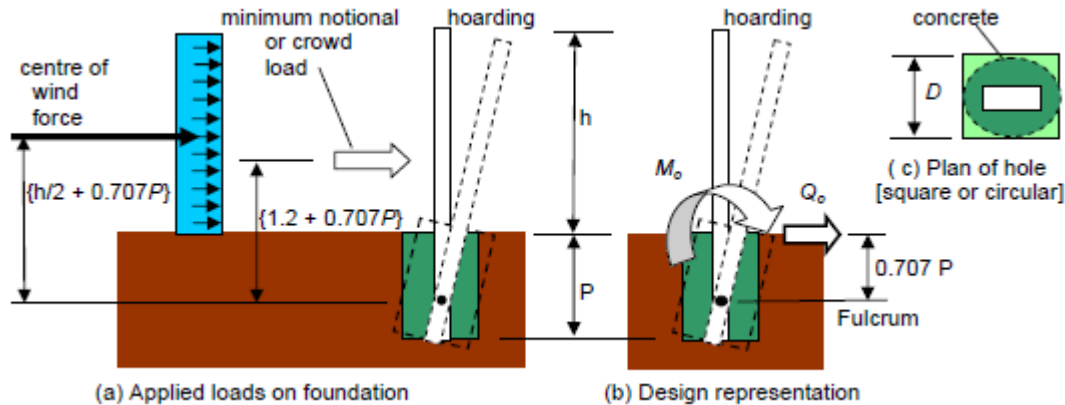
Point side penetration: $e_{\text{ss}} := 150\text{mm} - 50\text{mm} = 100\text{mm}$

Permissible load per connect.: $P_{Rd} := N_s \cdot e_s \cdot F_{\text{ww}} \cdot K_{52} \cdot K_{53} = 1.934 \cdot \text{kN} > P_p = 0.803 \cdot \text{kN}$
hence = "PASS"

NOTE: The rails are not continuous past the post, hence the loaded length is halved

CALCULATION		JOB No:	1646-01
 TWS DESIGN temporary works engineers	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF		PREPARED by MH
	TITLE: 2.4M HIGH HOARDING TO GROUND		CHECKED by TS
	CLIENT: SAFEFENCE		REVISION C0
		DATE:	24.04.2020

8. Foundation design:



Max. overturning forces about post base:

$$Q_0 := \max(Q_B \cdot \text{CRS}_B, Q_C \cdot \text{CRS}_C, Q_D \cdot \text{CRS}_D, Q_D \cdot \text{CRS}_{D.fe}) = 2.582 \cdot \text{kN}$$

$$M_0 := \max(M_B \cdot \text{CRS}_B, M_C \cdot \text{CRS}_C, M_D \cdot \text{CRS}_D, M_D \cdot \text{CRS}_{D.fe}) = 3.099 \cdot \text{kNm}$$

Ground resistance moment:

$$\text{Minimum effective width of concreted foundation:} \quad D := 0.35\text{m}$$

$$\text{Planting depth of the post from ground level:} \quad P := 0.9\text{m}$$

$$\text{Ground factor (for poor quality of the ground):} \quad G := 390 \frac{\text{kN}}{\text{m}^2}$$

(TWf2012: 01, Table D1)

$$M_{\text{ground}} := \frac{G \cdot D \cdot P^3}{10\text{m}} = 9.951 \cdot \text{kNm}$$

Max. overturning moment about fulcrum point:

$$M := [M_0 + (0.707 \cdot Q_0 \cdot P)] \cdot 1.5 = 7.113 \cdot \text{kNm} < M_{\text{ground}} = 9.951 \cdot \text{kNm}$$

hence = "PASS"

(with 1.5 factor of safety)

CALCULATION		JOB No:	1646-01
	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF	PREPARED by	MH
		CHECKED by	TS
	TITLE: 2.4M HIGH HOARDING TO GROUND	REVISION	C0
	CLIENT: SAFEFENCE	DATE:	24.04.2020

9. Design Summary:

1. Use **75x150 C24** constructional sawn timber posts at crs: 1.6m (in zone B - 3 bays), 1.8m (in zone C - 3 bays), 2.4m (in zone D - remainder) and 1.5m (in zone D_{FREE END} - 7 bays);
2. Use **3No. 100x50 C24** constructional sawn timber rails at **1220mm** centres;
3. Face material: **18mm Plywood**;
4. Use **50mm galvanised nails.....** for the ply to rail connection at **250mm** centres;
5. Use **100-150mm galvanised nails.....** per rail to post connection;
6. Posts to be embedded in to the ground in **350mm dia. hole, 900mm deep** and infilled with concrete - in case of average ground quality. **Upto 900mm deep minimum 750mm deep**

CALCULATION		JOB No:	1646-01
	PROJECT: CARNIVAL PHASE 2, WELLINGTON ROAD, WOKINGHAM RG40 2AF	PREPARED by	MH
		CHECKED by	TS
	TITLE: 2.4M HIGH HOARDING TO GROUND	REVISION	C0
	CLIENT: SAFEFENCE	DATE:	24.04.2020

APPENDIX A

Allowable internal forces
for timber beams
(TWf20125:01)

75x150mm C24timber posts

Geometry details:

$$a = 3 \cdot \text{in}$$

$$b = 6 \cdot \text{in}$$

Dimensions of cross-section:

$$A_s := a \cdot b = 112.5 \cdot \text{cm}^2$$

Section area:

$$I_y := \frac{a \cdot b^3}{12} = 2109.375 \cdot \text{cm}^4$$

Moment of inertia:

$$W_y := \frac{a \cdot b^2}{6} = 281.2 \cdot \text{cm}^3$$

Section modulus:

$$fZ = 7.5 \cdot \frac{\text{N}}{\text{mm}^2} \quad \text{Bending stress parallel to grain}$$

$$qA = 0.71 \cdot \frac{\text{N}}{\text{mm}^2} \quad \begin{array}{l} \text{Shear stress parallel to grain} \\ \text{(service class 3)} \end{array}$$

$$E_{0.\text{mean}} = 8640 \cdot \frac{\text{N}}{\text{mm}^2} \quad \begin{array}{l} \text{Mean modulus of elasticity} \\ \text{(service class 3)} \end{array}$$

$$E_{\text{min}} = 5760 \cdot \frac{\text{N}}{\text{mm}^2} \quad \text{Minimum modulus of elasticity:}$$

$$K_{2b} := 0.8 \quad \begin{array}{l} \text{Factor converting service classes 1 and 2 strength} \\ \text{classes to service class 3 (bending)} \end{array}$$

$$K_{2s} := 0.9 \quad \begin{array}{l} \text{Factor converting service classes 1 and 2 strength} \\ \text{classes to service class 3 (shear)} \end{array}$$

$$\text{Load sharing factor:} \quad K_8 = 1$$

$$\text{Duration of load factor:} \quad K_3 = 1.75$$

$$\text{Bearing stress factor:} \quad K_4 := 1.0$$

$$\text{Form factor:} \quad K_6 := 1.0$$

$$\text{Depth factor:} \quad K_7 = 1.079$$

PERMISSIBLE STRESSES

Shear load:

$$V_{\text{RdP}} := qA \cdot A_s \cdot K_{2s} \cdot K_3 \cdot K_4 \cdot K_6 \cdot K_8 = 12.58 \cdot \text{kN}$$

Moment of resistance:

$$M_{\text{RdP}} := fZ \cdot W_y \cdot K_{2b} \cdot K_3 \cdot K_4 \cdot K_6 \cdot K_7 \cdot K_8 = 3.187 \cdot \text{kN} \cdot \text{m}$$

100x50mm C24 timber rails with ply

Geometric details

Dimensions of cross-section: $a = 4 \cdot \text{in}$ $b = 2 \cdot \text{in}$

Section area: $A_{sa} := a \cdot b = 50 \cdot \text{cm}^2$

Moment of inertia: $I_{yy} := \frac{a \cdot b^3}{12} = 104.167 \cdot \text{cm}^4$

Section modulus: $W_{yy} := \frac{a \cdot b^2}{6} = 41.7 \cdot \text{cm}^3$

$f_Z = 7.5 \cdot \frac{\text{N}}{\text{mm}^2}$ Bending stress parallel to grain

$q_A = 0.71 \cdot \frac{\text{N}}{\text{mm}^2}$ Shear stress parallel to grain
(service class 3)

$E_{0.\text{mean}} = 8640 \cdot \frac{\text{N}}{\text{mm}^2}$ Mean modulus of elasticity
(service class 3)

$E_{\text{min}} = 5760 \cdot \frac{\text{N}}{\text{mm}^2}$ Minimum modulus of elasticity

Factor converting service classes 1 and 2 strength
classes to service class 3 (bending): $K_{2b} := 0.8$

Factor converting service classes 1 and 2 strength
classes to service class 3 (shear): $K_{2s} := 0.9$

Duration of load factor: $K_3 = 1.75$

Bearing stress factor: $K_4 := 1.0$

Form factor: $K_6 := 1.0$

Depth factor: $K_7 = 1.17$

Load sharing factor: $K_8 = 1$

Plywood used: 18mm Finish plywood

Characteristic mean modulus of elasticity in bending -
face grain perpendicular to span: $E_{\text{m.ply}} := 3350 \cdot \frac{\text{N}}{\text{mm}^2}$

Modification factor for creep deformation and
service class (table 38 BS EN 5268-2): $k_{\text{def}} := 0.0$

Duration of load and service class factor for
plywood (short and very short term - table 39 BS
EN 5268-2): $K_{36} := 1.43$

$$E_{d,ply} := \frac{E_{m,ply}}{1 + k_{def}} \cdot K_{36} = 4790.5 \cdot \frac{N}{mm^2}$$

Grade modulus value:

$$A_{ply} := 18mm \cdot a = 18 \cdot cm^2$$

Area of ply in the face contact with rail:

$$r := \frac{E_{0,mean}}{E_{d,ply}} = 1.804$$

Rail and plywood modulus of elasticity ratio:

$$I_{y,ply} := \frac{a \cdot (18mm)^3}{12} = 4.86 \cdot cm^4$$

Moment of inertia of ply section:

$$A_i := A_s + \frac{A_{ply}}{r} = 59.98 \cdot cm^2$$

Transformed area of the timber component

$$y_{dist} := \frac{b}{2} + \frac{18mm}{2} = 3.4 \cdot cm$$

Distance between centroid of ply section and centroid of rail section

$$y_{r1} := \frac{A_{ply}}{r \cdot A_i} \cdot y_{dist} = 5.657 \cdot mm$$

Distance between centroid of rail section and centroid of transformed timber component

$$y_{ply} := \frac{A_s}{A_i} \cdot y_{dist} = 2.834 \cdot cm$$

Distance between centroid of ply section and centroid of transformed timber component

$$y_c := y_{ply} + \frac{18mm}{2} = 3.734 \cdot cm$$

Distance between centroid of transformed timber component and top fibre of the section

$$y_{dc} := y_{r1} + \frac{b}{2} = 3.066 \cdot cm$$

Distance between centroid of transformed timber component and bottom fibre of the section

$$I_c := I_y + \frac{I_{y,ply}}{r} + A_s \cdot y_{dist} \cdot y_{r1} \dots = 203.036 \cdot cm^4$$

Moment of transformed timber component

$$W_{y,c} := \frac{I_c}{y_c} = 54.371 \cdot cm^3$$

Section modulus - top fibres

$$W_{y,dc} := \frac{I_c}{y_{dc}} = 66.227 \cdot cm^3$$

Section modulus - bottom fibres

$$W_y := \min(W_{y,c}, W_{y,dc}) = 54.4 \cdot cm^3$$

Min. section modulus

$$A_s := A_i = 59.98 \cdot cm^2$$

Section area

PERMISSIBLE STRESSES

Shear load:

$$V_{Rd2} := qA \cdot A_s \cdot K_{2s} \cdot K_3 \cdot K_4 \cdot K_6 \cdot K_8$$

$$V_{Rd2} = 6.707 \text{ kN}$$

Moment of resistance:

$$M_{Rd2} := fZ \cdot W_y \cdot K_{2b} \cdot K_3 \cdot K_4 \cdot K_6 \cdot K_7 \cdot K_8$$

$$M_{Rd2} = 0.668 \cdot \text{kNm}$$

geometric properties of transformed timber component

