

Job Title: Hoyland Sculpture				Date 3.22		Job no: 22052 rev A			
Subject:						Subject ref:			
Originator SW	Checked	Revision A	Revision 3.22	Revision					
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The following calculations are relevant to the proposed works intended for Hoyland Town Centre. The work consists of the introduction of a Billy & Kes statue as shown in the following pages.

The purpose of the enclosed calculations is to propose a design for the statue as well as its base such that it is adequately supported.

Due to the nature of the works, various assumptions are to be made so as to allow an adequate set of calculations to be created.

Any assumptions made will be clearly stated as such and it is the responsibility of the project's contractor or inspector to ensure any assumptions which have been made reasonably represent and fairly reflect the actual state of the site.

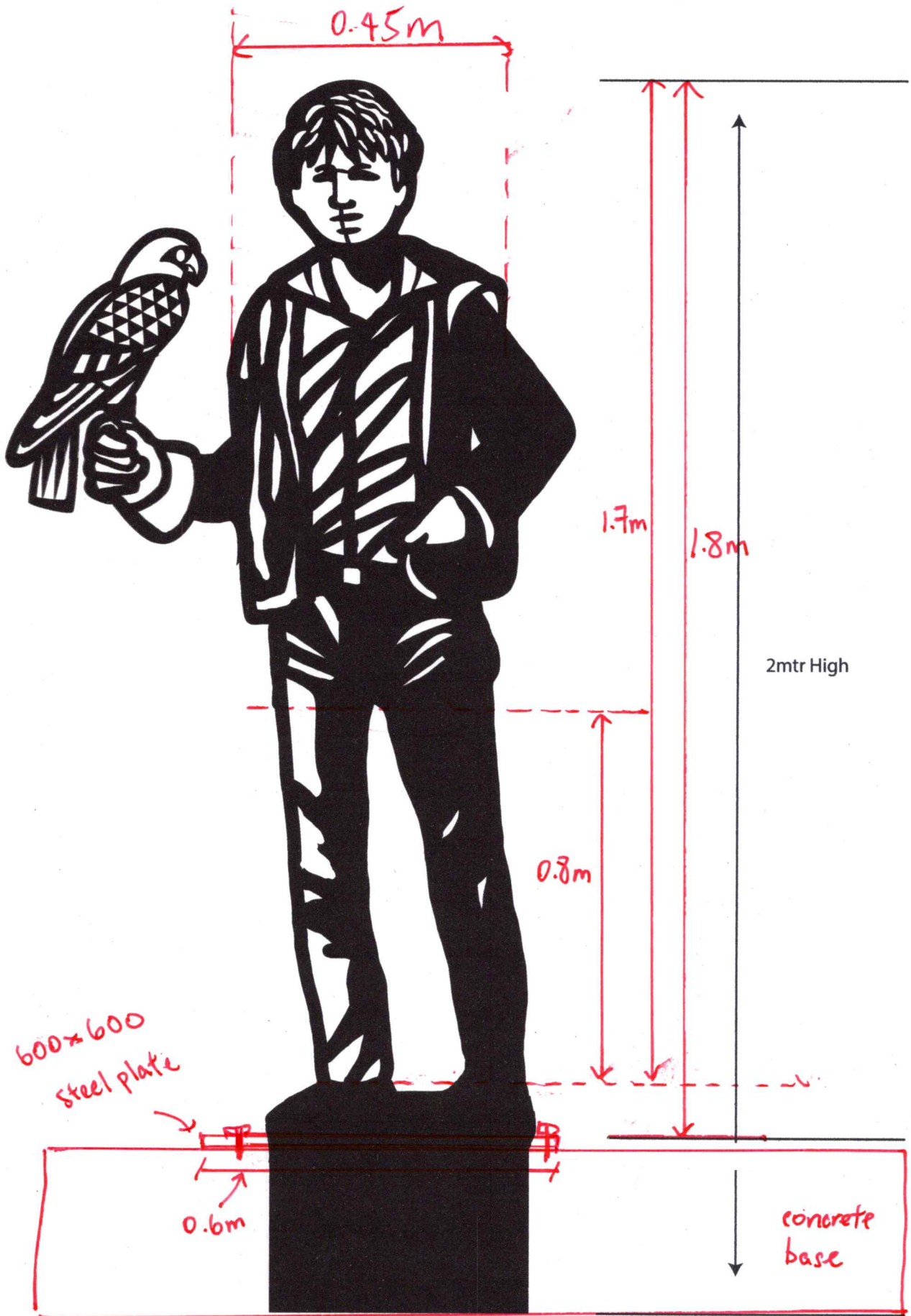
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First, the structure of the sculpture is to be tested to be adequate. This is to be done by testing where is the weakest or critical points / sections in the steel structure. The steel sections will then be designed to ensure these parts will not fail.

After this, a base design of concrete is to be determined such that the steel is to remain stable and upright.

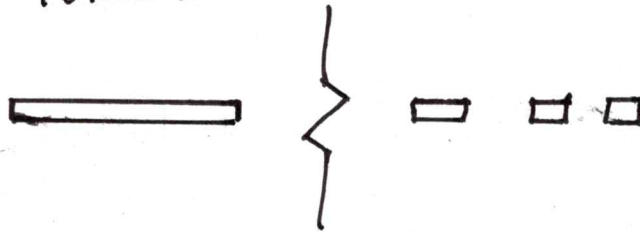
The sculpture will be welded to a 600x600 steel plate, which is then bolted into the concrete base. As such, the adequacy of the plate as well as the number of bolts needed will be determined as well.

All design are to be done taking the structure as cor-ten steel and are based on the drawing and dimensions provided in page 2a.



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The section of the ankles are provided as follows :



As there are gaps within the right ankle, its section is considered only half of left ankle.

This section will be used to design the maximum applied moments.

Wind Load :

$$\text{Wind Speed} = 23 \text{ m s}^{-1} = V_e$$

$$P_s = 0.613 V_e^2 = 324 \text{ Pa} \approx 0.324 \text{ kNm}^{-2}$$

$$W = P_i + P_e$$

$$= (k_i \cdot K_a \cdot P_s) + (k_e \cdot K_a \cdot P_s)$$

$$= [0.8 \times 0.99 \times 0.324] + [1.1 \times 0.99 \times 0.324]$$

$$\approx 0.6 \text{ kNm}^{-2}$$

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Section

Sheet

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of

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Approximating from the photo:

Total height of sculpture = 1.8m

height of shoes = 0.1m

⇒ Total height from ankle = 1.7m

Assuming width = 0.5m

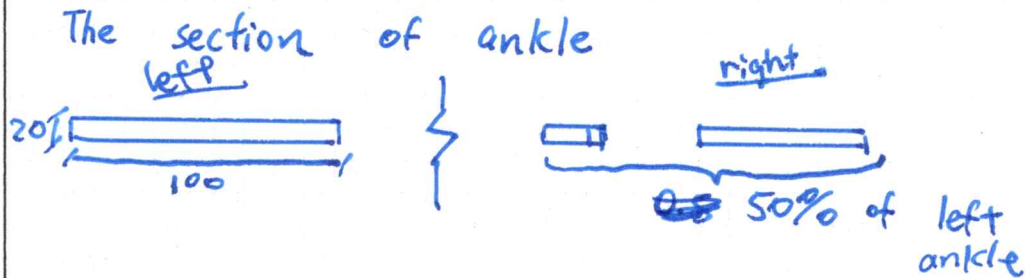
Dimension = $1.7m \times 0.5m = 0.85m^2$

Accounting gaps = $0.85 \times 0.5 = 0.425m^2$

Factored wind load = $1.4 \times 0.6 \times 0.425 = 0.357kN$

As the sculpture is holding a bird, it is assumed that the neutral axis of the full sculpture to be $\frac{3}{5}L = 1m$ from the ankle.

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⇒ Section modulus required

$$Z = \frac{M}{f}$$

$$M = wk \times lm = 0.357 \text{ kN} \times 1 \text{ m} \\ = 0.357 \text{ kNm}$$

Given $f = 213 \text{ N/mm}^2$ (Cor-ten steel)

$$\Rightarrow Z_{\text{req}} = \frac{0.357 \times 10^6}{213} = 1676 \text{ mm}^3$$

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$$I_{req} = 1676 \times \frac{20}{2} = 16760 \text{ mm}^4$$

current I_{des} of 20mm flat plate

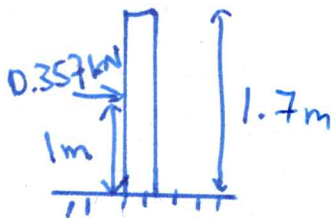
$$= \frac{100 \times 20^3}{12} = 66667 \text{ mm}^4$$

Accounting 0.5 factor for right ankle:

$$I_{des} = 66667 \times (1+0.5) = 100 \times 10^3 \text{ mm}^4 > I_{req}$$

⇒ Ankle section is okay.

Deflection check



$$L = 1700 \text{ mm}$$

$$a = 1000 \text{ mm}$$

$$b = 700 \text{ mm}$$

$$E = 205 \text{ kN/mm}^2$$

$$I_{ankle} = 100 \times 10^3 \text{ mm}^4$$

$$\delta_{des} = \frac{P a^3}{3EI} \left(1 + \frac{3b}{2a} \right) = \frac{0.357 \times 1000^3}{3 \times 205 \times 100 \times 10^3} \left(1 + \frac{3 \times 700}{2 \times 1000} \right)$$

$$= 11.9 \text{ mm}$$

$$\text{Assume } \delta_{max} = \frac{L}{5} = 340 \text{ mm} > \delta_{des}$$

⇒ OK =

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According to the design, the sculpture is to be welded to a 600×600 steel plate, which is then bolted to the underground concrete slab base.

Concrete base:

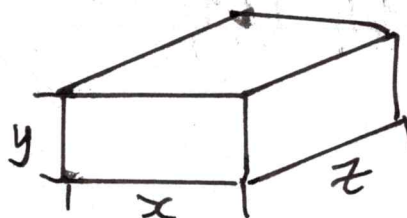
Assuming a point load of 0.357 kN horizontal as shown above.

$$M_{\text{APPLIED}} = M_A = 0.357 \times 1 \text{ m (NA)} \\ = 0.357 \text{ kNm}$$

$$M_{\text{resist}} = M_{\text{sw}} + M_{\text{Billey}}$$

where M_{sw} = moment induced by the base.

Take concrete base dimensions as;



$$V = x y z \quad , \quad \text{density on concrete} = 20 \text{ kNm}^{-3}$$

$$\text{Weight } S_w = 20 \times y z$$

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Assuming Billy ^{and Kes} weighs **2.5 kN**.

If forces are to act about centre of base,

$$\text{lever arm} = \frac{x}{2}$$

$$M_{res} = (2.5 + 20xyz) \frac{x}{2} \geq 0.357 \text{ kNm} \quad \leftarrow MA$$

As the steel plates above are about 600x600

Assume $x = z = 700 \text{ mm}$.

$$(0.875) + (3.43 y) \geq 0.357 \text{ kNm}$$

$$y \geq -0.151 \text{ m} \approx -151 \text{ mm}$$

Take concrete base as 700 x 700 x 150 mm.

Bearing Pressure check:

$$\text{Load on soil} = 2.5 + 1.47 \approx 4 \text{ kN} = R$$

$$MA = 0.357 \text{ kNm}$$

$$\text{eccentricity of load on soil} = \frac{(0.357 \times 0.15) + 0.357}{R}$$

$$= 0.102 \text{ m} = 100 \text{ mm}$$

$$L = x = 700 \text{ mm} \Rightarrow \frac{L}{6} = 117 \text{ mm} < e_r$$

$$\therefore \sigma_A = \frac{R}{BL} + \frac{R e_r}{BL^2/6}$$

$\Rightarrow$ OK =

$$= 15.16 \approx 15 \text{ kN/m}^2 \text{ (SBS worst case)}$$

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steel
plate
Design

$$F = 0.5 \text{ kNm/10mm} = 50 \text{ kN (shear at bolts)}$$

Taking bolts in resin/concrete, Rawl Plug data:

Using R-KM2 / polyester resin:

$$V_A = 50 \text{ kN}$$

$$V_{cap} = 18.59 \text{ kN (M12) (A4 studs)}$$

$$\text{or } 35.26 \text{ kN (M16) (A4 studs)}$$

$$\Rightarrow \begin{cases} 50 / 18.59 = 2.69 = 3 \text{ bolts of M12} \\ 50 / 35.26 = 1.42 = 2 \text{ bolts of M16} \end{cases}$$

spacing : $\begin{cases} \text{or } 3 \text{ No. M12 bolts @ } 275 \text{ ctrs } \star \\ \underline{2 \text{ No. M16 bolts @ } 550 \text{ ctrs.}} \end{cases}$

Moment capacity check

$$t = 20 \text{ mm (thickness of plate)}$$

$$Z_x = \frac{600 \times 20^2}{6} = 40000 \text{ mm}^3$$

$$M_{cap} = 213 \text{ N/mm}^2 \times 40000 \text{ mm}^3 = 8.52 \text{ kNm}$$

$$M_A = 0.5 \text{ kNm} \Rightarrow \text{OK}$$

