<table>
<thead>
<tr>
<th>Design Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
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<tr>
<td>Client:</td>
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<tr>
<td>Scaffolding Contractor:</td>
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<tr>
<td>Title:</td>
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<td>Calculation Number:</td>
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<tr>
<td>11</td>
</tr>
<tr>
<td>11</td>
</tr>
</tbody>
</table>
**Technical Information**

**Project:** Mezzanine storage area on stacked containers  
**Site:** - Generic -  
**Client:** BARRATT HOMES  
**Project Number:** CS 9488  
**Date:** 27/04/2017

### British Standards

- **BS 1139-1.2: 1990** Metal scaffolding
- **BS 2482: 2009** Timber scaffold boards
- **BS 5950-1: 2000** Structural use of steelwork in building
- **BS 5973: 1993** Access and working scaffolds and special scaffold structures in steel
- **BS 5974: 2010** Temporary suspended access equipment
- **BS 5975: 2008 +A1: 2011** Temporary works procedures and the permissible stress design of falsework
- **BS 6399-2: 1997** Wind loads
- **BS 6399-3: 1988** Imposed roof loads
- **BS 8118-1: 1991** Structural use of aluminium
- **BS EN 12810-1:2003** Façade scaffolds made of prefabricated components
- **BS EN 12811-1:2003** Temporary works equipment. Scaffolds. Performance requirements and general design
- **BS EN 13374:2004** Temporary edge protection systems. Product specification, test methods
- **BS EN 39: 2001** Loose steel tubes for tube and coupler scaffolds. Technical delivery conditions

(1) Status: Superseded, Withdrawn

### Relevant Industry Guides

- **HSG 33: 2008** Health and safety in roof work
- **SG28:09** Safe system of work for scaffolding associated with timber frame building construction
- **SG4:15** Preventing falls in scaffolding. Management guide
- **TG4:11** Anchoring systems
- **TG20:13** Guide to good practice for scaffolding with tubes and fittings + Supplement 1

### Regulations

- The Work at Height (Amendment) Regulations 2007
- The Construction (Design and Management) Regulations 2015 (CDM)

### Other Information

#### Safe working loads:

<table>
<thead>
<tr>
<th>Description</th>
<th>B.M. (kN)</th>
<th>Shear (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel scaffold tube</td>
<td>1.00</td>
<td>26.10</td>
</tr>
<tr>
<td>Aluminium scaffold tube</td>
<td>1.33</td>
<td>25.50</td>
</tr>
<tr>
<td>610mm Steel Unit Beam</td>
<td>27.70</td>
<td>13.20</td>
</tr>
<tr>
<td>305mm Ladder Beam</td>
<td>12.00</td>
<td>15.00</td>
</tr>
<tr>
<td>38mm thick scaffold board</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>50mm scaffold board</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>S.W.L (slip) BS1139 Right-angle coupler</td>
<td>6.10 kN</td>
<td></td>
</tr>
<tr>
<td>S.W.L (slip) BS1139 Swivel coupler</td>
<td>6.10 kN</td>
<td></td>
</tr>
</tbody>
</table>

#### Weights of Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel tube</td>
<td>4.37</td>
</tr>
<tr>
<td>Aluminium tube</td>
<td>1.66</td>
</tr>
<tr>
<td>Unit Beam</td>
<td>14.50</td>
</tr>
<tr>
<td>Ladder Beam</td>
<td>13.10</td>
</tr>
<tr>
<td>38mm thick boards</td>
<td>6.00 kg/m</td>
</tr>
<tr>
<td>50mm thick boards</td>
<td>8.00 kg/m</td>
</tr>
<tr>
<td>Fittings</td>
<td>1.25 kg</td>
</tr>
</tbody>
</table>
1.0 Design Assumptions

The ground upon which the scaffold is based is capable of sustaining the loads imposed by the scaffold standards.

The imposed design loading is suitable for the works to be carried out, and will be monitored at all times whilst the scaffold is in use.

The client and the scaffolding contractor should check all of the above and ensure that all assumptions made are correct and appropriate for the works to be carried out.

2.0 Loading Conditions

2.1 Maximum load on storage platform must not exceed: 1.50 tons per container area

i.e. = 14.94 kN

Area per container ‘roof’ = 2.4m x 6.1m = 14.64 m²

Equivalent to a UDL of = 1.02 kN/m² Container deck

2.2 Maximum load on staircase must not exceed: 1.50 kN/m² Staircase

2.0 Wind Loading (BS EN 1991-1-4: 2005)

2.1 Basic wind velocity $V_{b,0}$

$V_{b,0} = V_{b,\text{map}} \times C_{\text{alt}}$

$V_{b,\text{map}} = 25$ m/s Figure NA.1

$C_{\text{alt}} = 1 + 0.001 \times A$ for $z \leq 10$m

$z = z_e$ \hspace{1cm} $h \leq b$

$z_e = 1.50$ m Reference height, $Z_e$ as defined in BS EN 1991-1-4:2005 Figure 7.4

$A = 150.0$ m $A$ is the altitude of the site in metres above mean sea level

$C_{\text{alt}} = 1.150$

$V_{b,0} = 28.75$ m/s

2.2 Basic Wind Velocity: $V_b$

Section 4.2

$V_b = C_{\text{dir}} \times C_{\text{season}} \times V_{b,0} \times C_{\text{prob}}$

$C_{\text{dir}} = 1.00$ For all directions Table NA.1

$C_{\text{season}} = 1.00$ For all seasons Table NA.2

$C_{\text{prob}} = (\frac{(1 - K \cdot \ln(-\ln(1 - p)))}{1 - K \cdot \ln(-\ln(0.98))})^n$ Expression (4.2)

$K = 0.2$ NA.2.8
Design Calculations

Project: Mezzanine storage area on stacked containers
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Project Number: CS 9488
Date: 27/04/2017

2.3 Mean Wind: $V_n(z)$

\[
V_n = \frac{1}{2} \rho V_b
\]

Upwind distance to sea = 1 km
\[z - h_{dis} = 1.5 \text{ m}\]

2.4 Peak Velocity Pressure: $q_p(z)$

\[
q_p(z) = c_e(z) \times q_b \quad \text{for sites in Country terrain}
\]
\[
c_e(z) = 1.90 \quad \text{Zone B} \quad \text{Figure NA.7}
\]
\[
q_b = 0.613 \times \left(\frac{V_b^2}{10^3}\right) \quad \text{Figure A.NA.1}
\]
\[
q_b = 0.36 \text{ kN/m}^2
\]
\[
q_p(z) = 0.69 \text{ kN/m}^2
\]

2.5 Wind Pressure on Surfaces: $W_e$

\[
W_e = q_p(z) \times c_{pe}
\]

2.6 Force coefficients,

2.6.1 Scaffold tube force coefficient, $c_{f,tube} = 1.20$ (TG20:13)

For individual components, structural factor, $c_{sd} = 1.00$

Wind load on tubes (wind on front/rear), $P_{tube,front} = 0.82 \text{ kN/m}^2$

2.7 Snow Loading (BS EN 1991-1-3:2003)

\[
s = \mu_i \times C_e \times C_i \times s_k
\]
\[
\mu_i = 0.8 \quad 0^\circ < \alpha < 30^\circ \quad \text{Table NA.1}
\]
\[
C_e = 1.0 \quad \text{NA.2.15}
\]
\[
C_i = 1.0 \quad \text{NA.2.16}
\]
\[
s_k = [0.15 + (0.1Z + 0.05)] + [(A - 100) / 525] \quad \text{NA.2.8}
\]
\[
Z = 3.00 \quad \text{Figure NA.1}
Design Calculations

Project: Mezzanine storage area on stacked containers
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Project Number: CS 9488 Date: 27/04/2017

A = 150.0 Alt < 1500m

\[ s_k = 0.60 \text{ kN/m}^2 \]

50 year return period

\[ s = 0.48 \text{ kN/m}^2 \]

Adjustment of the ground snow load for return period

\[ n = 10 \text{ Return period in years} \]

\[ P_n = 0.10 \text{ Annual probability of exceedence} \]

\[ V = 0.90 \text{ Coefficient of variation of annual max. snow load} \]

\[ s_n = 0.39 \text{ kN/m}^2 \text{ Formula D.1} \]

\[ s = 0.31 \text{ kN/m}^2 \]

3.0 Scaffolding components - Staircase: UDL not exceeding 1.5 kN/m²

3.1 Stairtreads: Apollo stairtreads are rated at 5.0 kN/m²

\[ 5.00 > 1.50 \text{ therefore Design OK.} \]

3.2 Half Landings:

Boards

Dimension of standard scaffold board = 230 mm x 38 mm

Maximum board span = 0.615 m

Self weight of 38mm thick timber scaffold board = 0.25 kN/m²

Snow load on landing = 0.31 kN/m²

UDL on landing = 1.50 kN/m²

Total load on working platform = 2.06 kN/m²

Load per board span (W_b) = (2.06 kN/m² x 0.23m x 0.62m)

\[ W_b = 0.29 \text{ kN} \]

BM in board = \( W_bL/8 \)

\[ = 0.02 \text{ kNm} \]

Permissible BM in 38mm thick timber scaffold board = 0.468 kNm

\[ 0.468 > 0.02 \text{ therefore Design OK.} \]
3.3 Transoms

Maximum transom span under working platform = 1.22 m

Load per transom span ($W_t$) = $2.06 \, \text{kN/m}^2 \times 0.61 \, \text{m} \times 1.22 \, \text{m}$

$W_t = 1.55 \, \text{kN}$

$\text{BM in transom} = \frac{W_t \times L}{8}$

= 0.24 kNm

Permissible BM in steel scaffold tube (TG20:13) = 1.12 kNm (BS 1139-1-1:1990 tube)

$1.12 > 0.24$ therefore Design OK.

3.4 Ledgers

Maximum ledger span under working platform = 1.33 m

Worst load case occurs with a single transom located at mid-span:

Transom end reaction = 0.77 kN

$\text{BM in ledger} = \frac{W_t \times L}{4}$

= 0.26 kNm

Permissible BM in steel scaffold tube (TG20:13) = 1.12 kNm (BS 1139-1-1:1990 tube)

$1.12 > 0.26$ therefore Design OK.

3.5 Stringers

3.5.1 Maximum tread area = 0.23 m x 1.2 m = 0.276 m$^2$

Load per tread = $0.276 \, \text{m}^2 \times 2.06 \, \text{kN/m}^2 = 0.57 \, \text{kN}$

Maximum stringer span under treads = 2.06 m

Worst load case occurs when tread located at mid-span:

Tread end reaction = 0.284 kN

0.284 0.284 0.284 0.284 0.284 0.284 0.284 kN

0.15m 0.44m 0.74m 1.03m 1.32m 1.62m 1.91m

Ra

0m

Rb

2.06m
3.5.2 Analysis:

![Diagram of steel scaffold tube with bending moment, shear force, and deflection graphs.]

Bending Moment:
- Largest Positive = +0.547 kNm
- Largest Negative = 0.000 kNm

Shear Force:
- Largest Positive = +1.04 kN
- Largest Negative = -1.04 kN

Deflection:
- Largest Positive = +8.2 mm
- Largest Negative = 0.0 mm

Permissible BM in steel scaffold tube (TG20:13) = 1.12 kNm (BS 1139-1:1:1990 tube)

3.6 Connection to Standards

Max reaction at standard (or Raker) = 1.00 kN

slip capacity of the couplers: 1 no. BS1139 coupler = 6.10 kN

6.10 > 1.00 therefore Design OK.

3.7 Standards

3.7.1 Self weight of scaffold:

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Length (m)</th>
<th>Weight (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>1</td>
<td>3.80</td>
<td>3.80</td>
</tr>
<tr>
<td>Ledger</td>
<td>2</td>
<td>1.44</td>
<td>2.88</td>
</tr>
<tr>
<td>H'rail</td>
<td>2</td>
<td>0.70</td>
<td>1.40</td>
</tr>
<tr>
<td>Transom</td>
<td>3</td>
<td>0.75</td>
<td>2.25</td>
</tr>
<tr>
<td>Face brace</td>
<td>2</td>
<td>0.90</td>
<td>1.80</td>
</tr>
<tr>
<td>Ledger brace</td>
<td>2</td>
<td>0.90</td>
<td>1.80</td>
</tr>
<tr>
<td>Plan brace</td>
<td>1</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>Stringer/G'rails</td>
<td>3</td>
<td>0.90</td>
<td>2.70</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>17.43</strong></td>
<td></td>
</tr>
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</table>
Design Calculations

Project: Mezzanine storage area on stacked containers
Site: - Generic -
Client: BARRATT HOMES
Project Number: CS 9488 Date: 27/04/2017

Design Calculations

3.7.2 Self weight of boards + Imposed load + snow
Landing platform

\[ 0.60 \text{ m} \times 0.6 \text{ m} = 0.360 \text{ m}^2 \]
\[ 0.360 \text{ m}^2 \times 2.06 \text{ kN/m}^3 = 0.74 \text{ kN} \]

3.7.3 Stairs
Reaction from Stringer (Treads plus imposed) = 1.00 kN

3.7.4 Total vertical load in leg = 2.68 kN
Permissible axial load in 1400mm strut (TG20:13 Table D1) = 45.00 kN

\[ 45.00 > 2.68 \text{ therefore Design OK.} \]

Ground bearing pressure:
Standards to be footed on 150mm x 150mm M.S. baseplates on 38mm x 450 timber sole pads.
Assume 45° dispersion from 150 sq. baseplate,
Effective area under sole board = 0.302 m x 0.225 m = 0.07 m\(^2\)
Therefore, ground bearing pressure generated under sole board = 39.51 kN/m\(^2\)

4.0 Bracing: Rigidity

5.1 Face Bracing: Wind parallel to Façade:
Take full end area, overall Cf as 1.2:
Area = 3.8m x 1.33m = 5.05 m\(^2\)
Wind pressure normal to façade \(W_e\) (see 2.6.1) = 0.82 kN/m\(^2\)
Positive wind load on face = 4.17 kN

5.2 Take 2.5% of imposed load:
Area of deck = 1.20 m x 5.50m = 6.60 m\(^2\)
Landings & treads, Imposed load + snow = 1.81 kN/m\(^2\)
Total = 10.86 kN
2.5% of Imposed load = 0.27 kN
Total Horizontal load = 4.44 kN

5.4 Brace capacity:
Axial capacity of brace depends on coupler capacity:
1 number BS1139 Type A Double coupler at 6.10 kN ea = 6.10 kN
Wind induced load factor x 1.25 = 7.63 kN
Resultant horizontal capacity, face brace = \((1220 / 1663) \times 7.63\) kN
\[
\begin{align*}
1663 & \quad 1130 \\
1220 & \quad = 5.60\text{ kN}
\end{align*}
\]

No. of braces = 2

Brace capacity = 11.20 kN

11.20 > 4.44 therefore OK

### 6.0 Scaffolding Components - Storage area on Container

#### 6.1 Boards

Width of standard scaffold board \((L_w)\) = 0.225 m

Maximum transom centres to working platform \((t_{cc})\) = 1.20 m max

#### 6.1.1

Self weight of 38mm thick timber scaffold board = 0.25 kN/m²

Imposed load = 1.02 kN/m²

Snow load = 0.31 kN/m²

Total load on upper working platform \((W)\) \((IL + S.Wt + snow)\) = 1.58 kN/m²

Load per board span \((W_b)\) = \(L_w \times t_{cc} \times W\)

\[
W_b = 0.43\text{ kN}
\]

BM in board = \(W_bL/8\)

where \(L = t_{cc}\)

BM = 0.06 kNm

Permissible BM in 38mm thick timber scaffold board (TG20) = 0.48 kNm

0.48 > 0.06 therefore OK

#### 6.2 Transoms

Maximum transom span under working platform \((L_t)\) = 1.00 m

Load per transom span \((W_t)\) = \(L_t \times t_{cc} \times W + Tself weight\)

\[
W_t = 1.94\text{ kN}
\]

BM in transom = \(W_tL/8\)

= 0.24 kNm

Permissible BM in steel scaffold tube (BS 1139 tube - TG20) = 1.12 kNm

(BS 1139-1-1:1990 tube)

1.12 > 0.24 therefore OK
6.3 **Ledgers**

Worst case BM with transom as mid-point load:

- Maximum ledger span under working platform = 2.40 m
- Maximum transom span under working platform = 1.20 m

Load on transom from main platform ($W_t$):

\[
W_t = 1.94 \text{ kN}
\]

BM in ledger from CPL = PL/5 = 0.93 kNm

BM in ledger from 0.1kN self wt = WL/8 = 0.03 kNm

\[0.96 \text{ kNm}\]

Permissible BM in steel scaffold tube (BS1139 tube - TG20:13) = 1.12 kNm

(BS 1139-1-1:1990 tube)

\[1.12 > 0.96 \text{ therefore Design OK}\]

6.4 **Stub Standards: Connections**

**Considering typical mid standard, 1.20m x 2.4m grid:**

6.4.1 **Self weight of tube and fittings:**

<table>
<thead>
<tr>
<th></th>
<th>1 no.</th>
<th>0.30 m</th>
<th>= 0.30 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ledgers</td>
<td>1 no.</td>
<td>2.40 m</td>
<td>= 2.40 m</td>
</tr>
<tr>
<td>Transoms</td>
<td>2 no.</td>
<td>1.20 m</td>
<td>= 2.40 m</td>
</tr>
</tbody>
</table>

Total = 5.10 m

Self weight of scaffold tube = 5.10 m x 4.37 kg/m = 22.29 kg

<table>
<thead>
<tr>
<th>Fittings</th>
<th>5 no.</th>
<th>1.25 kg each</th>
<th>= 6.25 kg</th>
</tr>
</thead>
</table>

Total self weight of tube & fittings = 28.54 kg

= 0.28 kN

6.4.2 **Self weight of 38mm boards:**

<table>
<thead>
<tr>
<th>2.40 m</th>
<th>x</th>
<th>1.20 m</th>
<th>= 2.88 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.88 m²</td>
<td>x</td>
<td>0.25 kN/m²</td>
<td>= 0.72 kN</td>
</tr>
</tbody>
</table>

6.4.3 **Imposed loading**

<table>
<thead>
<tr>
<th>1.02 kN/m²</th>
<th>2.40 m</th>
<th>x</th>
<th>1.20 m</th>
<th>= 2.88 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.88 m²</td>
<td>x</td>
<td>1.02 kN/m²</td>
<td>= 2.94 kN</td>
<td></td>
</tr>
</tbody>
</table>

6.4.4 **Snow loading**

<table>
<thead>
<tr>
<th>2.40 m</th>
<th>x</th>
<th>1.20 m</th>
<th>= 2.88 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.88 m²</td>
<td>x</td>
<td>0.31 kN/m²</td>
<td>= 0.89 kN</td>
</tr>
</tbody>
</table>

Total vertical load in stub standard = 4.83 kN

Axial capacity of connection depends on coupler capacity:

1 number BS1139 Type A Double coupler at 6.10 kN ea = 6.10 kN

\[6.10 > 4.83 \text{ therefore Design OK}\]

End of Calculations