APOLLO SALES LTD
SITE SCAFFOLD STEP
DESIGN CHECK CALCULATIONS

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Brief

To carry out a design check on the Apollo Site Tread scaffold step to the relevant Standards and Codes.

Layout

The step varies in length, supplied up to 1.5m wide tread taking into account the connection the span is taken as 1.6m

The step is 225mm wide with a non slip grating.

Section

From BS 5395 Stairs Ladders and walkways the min going is 225mm

```
45mm
      /
     /|   
    / |  
   /  | 

15mm 195 mm

225 mm
```

Loading

BS EN 12811-1 Cl6.2.4 Access routes

For stairways built for access to a working scaffold, each tread and landing shall be designed to support the more unfavourable of:

either
a) a single load of 1,5 kN in the most unfavourable position, assumed to be uniformly distributed over an area of 200 mm x 200 mm or over the actual width if it is less than 200 mm,
or
b) an uniformly distributed load of 1,0 kN/m2.

The structure of the stairways shall be capable of supporting a uniformly distributed load of 1,0 kN/m2 on all treads and landings within a height of 10 m.
Factor of safety

From BS EN 12811-1

1.1.1.1 Partial safety factors for actions, \( g_F \)

Except where stated otherwise, the partial safety factors, \( g_F \), shall be taken as follows:

Ultimate limit state
\[
\gamma_F = 1.5 \text{ for all permanent and variable loads} \\
\gamma_F = 1.0 \text{ for accidental loads}
\]

Serviceability limit state
\[
\gamma_F = 1.0
\]

10.3.2.2 Partial safety factors for resistance \( g_M \)

For the calculation of the design values of the resistances of steel or aluminium components the partial safety factor, \( \gamma_M = 1.1 \) for components of other materials the partial safety factor, \( g_M \), is to be taken from relevant standards.
Section properties

From autocad massprop using the section as shown below
This is conservative as the section chosen is the minimum

6mm

\[ r = 6\text{mm} \]

\[
\begin{align*}
A &= 441 \text{ mm}^2 \\
I_x &= 123982 \text{ mm}^4 \\
I_y &= 3691175 \text{ mm}^4 \\
r_x &= 16.8 \text{ mm} \\
r_y &= 91.5 \text{ mm} \\
W_{el,x} &= 4129 \text{ mm}^3 \\
W_{el,y} &= 32810 \text{ mm}^3 \\
\end{align*}
\]

Slenderness

\[
\frac{C}{t} = \frac{213}{6} = 35.50
\]

Section is class so plastic design allowable but elastic design chosen

Material is mild steel \( f_y = 275\text{N/mm}^2 \)

Moment capacity

From BS EN 1993-1-1- 6.2.5

\[
M_{c,Rd} = \frac{W_{el} f_y}{\gamma_M} = 4.13\text{cm}^3
\]

\[ f_y = 275\text{N/mm}^2 \]

\[ \gamma_M = 1.1 \]

\[
= 4.13 \times 275/1100 = 1.03 \text{kNm}
\]

Shear capacity

From BS EN 1993-1-1- 6.2.6

\[
V_{c,Rd} = A_v (f_y/\sqrt{3})/\gamma_M
\]

\[ A_v = 2 \times 45^2 = 180\text{mm}^2 \]

\[ f_y = 275\text{N/mm}^2 \]

\[
= 180 \times (275/\sqrt{3})/1100 = 25.98 \text{kN}
\]

Lateral Torsional Buckling

From BS EN 1993-1-1- 6.3.2.1

As bending is about minor axis LTB verification is not required.
Loading

As before

UDL on stair \( w = 1.00 \text{ kN/m}^2 \)
and point load \( W = 1.50 \text{ kN on 200mm by 200mm} \)

Moment

so for UDL on 225mm wide stair with span of 1.6m

\[
M_{Ed} = \gamma w B L^2 / 8 \\
\gamma = 1.5 \\
w = 1 \text{kN/m}^2 \\
B = 0.225 \text{m} \\
L = 1.6 \text{m} \\
= 1.5 \times 1 \times 0.225 \times 1.6^2 / 8 \\
= 0.14 \text{kNm}
\]

for a point load of 4kN over a width of 200mm

\[
W_u = \gamma W \\
\gamma = 1.5 \\
= 1.5 \times 1.5 \\
= 2.25 \text{kN}
\]

\[
Ra = \frac{W_u}{2} \\
W_u = 2.25 \text{kN} \\
Ra = 2.25 / 2 \\
= 1.13
\]

\[
M_{Ed} = Ra L / 2 \gamma W_u s / 16 \\
s = 0.2 \text{m} \\
W_u = 2.25 \text{kN} \\
B = 0.225 \text{m} \\
L = 1.6 \text{m} \\
= 1.13 \times 1.6 / 2 \times 2.25 \times 0.2 / 16 \\
= 0.85 \text{kNm}
\]

from previous calculations

\[
M_{Ed} = 1.03 \text{kNm} \\
> 0.85 \text{ ok}
\]
Shear

so for UDL on 225mm wide stair with span of 1.6m

\[ V_{Ed} = \gamma \cdot w \cdot B \cdot L / 2 \]

\[ \gamma = 1.5 \]

\[ w = 1 \text{kN/m}^2 \]

\[ B = 0.225 \text{m} \]

\[ L = 1.6 \text{m} \]

\[ = 1.5 \cdot 1 \cdot 0.225 \cdot 1.6 / 2 \]

\[ = 0.27 \text{kN} \]

for a point load of 4kN over a width of 200mm

\[ W_u = \gamma W \]

\[ \gamma = 1.5 \]

\[ = 1.5 \cdot 1.5 \]

\[ = 2.25 \text{kN} \]

\[ \text{W} \]

from previous calculations

\[ M_{Ed, Rd} = 25.98 \text{kN} \]

\[ > 1.13 \text{kN} \]

ok

Deflection

for central point load of 1.5kN

\[ d = W L^2 / 48 E I \]

\[ W = 1.5 \text{kN} \]

\[ L = 1.6 \text{m} \]

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

\[ I = 123982 \text{mm}^4 \]

\[ = 1500 \cdot 1600 \cdot 3 / (48 \cdot 205E3 \cdot 123982) \]

\[ = 5.04 \text{ mm} \]

From BS EN 12811-1 the max deflection is

\[ d = L / 100 \]

\[ = 1600 / 100 \]

\[ = 16.00 \text{ mm} \]

\[ > 5.04 \text{ mm} \]

ok
Rotation

If the loading was eccentric, i.e. at the step edge the moment applied to the support couplers would be

\[ M = Wu \cdot la \]

\[ Wu = 2.25 \text{kN} \]

\[ la = 0.225/2 \]

\[ = 0.11 \text{m} \]

\[ = 2.25 \times 0.11 \]

\[ = 0.248 \text{ kNm} \]

This is conservative as the load is spread over a patch not a point.

This is resisted by two couplers so the twisting moment is

\[ M = 0.124 \text{ kNm} \]

From BS EN 12811-1 the resistance to rotation of a double coupler is

\[ Mr = 0.130 \text{ kNm} \]

\[ > 0.124 \text{ kNm} \]

\[ \text{ok} \]

If the load is considered as a patch 200mm wide on a 225mm wide step then the eccentricity

\[ la = 225/2 - 200/2 \]

\[ = 12.50 \text{ mm} \]

and \[ M = Wu \cdot la \]

\[ = 2.25 \times 0.0125 \]

\[ = 0.03 \text{ kNm} \]

\[ \ll 0.13 \text{ kNm} \]

\[ \text{ok} \]
Length of stringer

From BS EN 12811-1, the load on the stringer is:

The structure of the stairways shall be capable of supporting a uniformly distributed load of 1,0 kN/m² on all treads and landings within a height of 10 m.

so the stringer will carry the load as shown below

\[
\begin{align*}
\text{w} &= 1.0 \text{kN/m}^2 \times \frac{1.6}{2} \\
&= 1.0 \times 1.6/2 \\
&= 0.80 \text{kN/m unfactored}
\end{align*}
\]

and

\[
\begin{align*}
L &= \text{length between stringer supports} \\
H &= \text{height varies with angle between 30 and 55 deg}
\end{align*}
\]

taking allowable values from TG20 as

\[
\begin{align*}
\text{Moment } M &= 1.1 \text{kNm} \\
\text{Axial } P &= \text{kN for 8m}
\end{align*}
\]

<table>
<thead>
<tr>
<th>Angle °</th>
<th>Moment kNm</th>
<th>Axial kN</th>
<th>Combined</th>
<th>Length m</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0.96</td>
<td>1.33</td>
<td>1.00</td>
<td>2.88</td>
</tr>
<tr>
<td>35</td>
<td>0.93</td>
<td>1.55</td>
<td>1.00</td>
<td>2.76</td>
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<tr>
<td>40</td>
<td>0.90</td>
<td>1.76</td>
<td>1.00</td>
<td>2.62</td>
</tr>
<tr>
<td>45</td>
<td>0.85</td>
<td>1.97</td>
<td>1.00</td>
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<tr>
<td>50</td>
<td>0.81</td>
<td>2.17</td>
<td>1.00</td>
<td>2.28</td>
</tr>
<tr>
<td>55</td>
<td>0.75</td>
<td>2.37</td>
<td>1.00</td>
<td>2.07</td>
</tr>
</tbody>
</table>

Above table found by Excel Goal seeking
Summary

The scaffold step has been checked for the required loading and found to be adequate for a maximum width of 1.5m.

Loading from BS EN 12811-1 Cl6.2.4 Access routes

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The stringer which supports the steps requires to be supported by standards at a spacing as shown in the table below dependant on the angle of the stair.

<table>
<thead>
<tr>
<th>Angle Degrees</th>
<th>Standard Spacing m</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>2.88</td>
</tr>
<tr>
<td>35</td>
<td>2.76</td>
</tr>
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<td>2.62</td>
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<td>2.28</td>
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<tr>
<td>55</td>
<td>2.07</td>
</tr>
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