APOLLO SALES LTD
ANGLE BRACKET
DESIGN CHECK CALCULATIONS

Alan N White B.Sc., M.Eng., C.Eng., M.I.C.E., M.I.H.T.

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Somerset House
11 Somerset Place
GLASGOW G3 7JT
Tel:0141 354 6579
Fax:0141 354 6549

CALCULATION SHEET	Project :	Apollo Angle Bracket		
	Element :	Brief		
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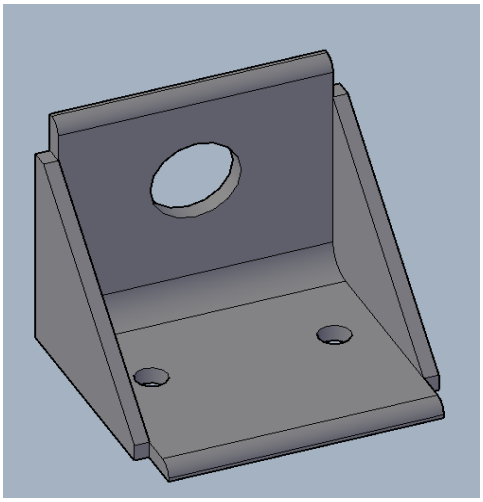
ALAN WHITE DESIGN

Brief

To carry out design check calculations on a steel angle bracket for Apollo which will tie scaffolding to a surface

This report provides the rated capacity of the steel angle bracket itself and gives a suggested connection to a concrete surface

Layout



Bracket Properties

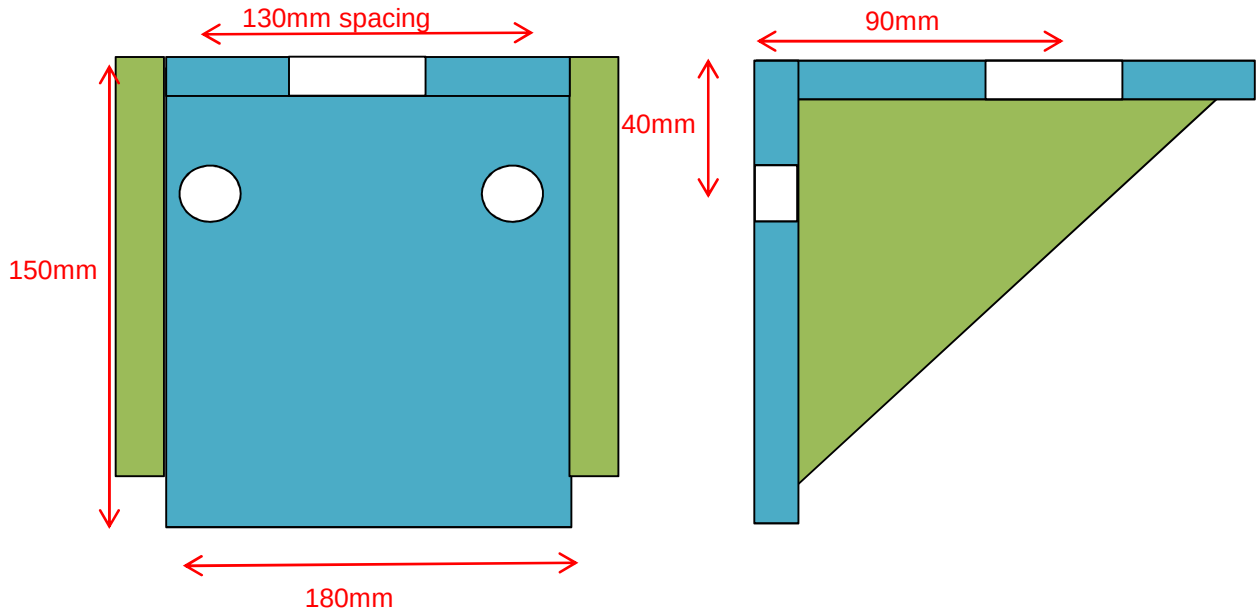
150 x 150 x 10 EA

S275

2No x 10mm Gussets 125 by 125

ø50mm scaffold tube vertical hole

2No ø18mm horizontal connection hole



Design

Eurocode 3 Design of steel structures BS EN 1993-1-1

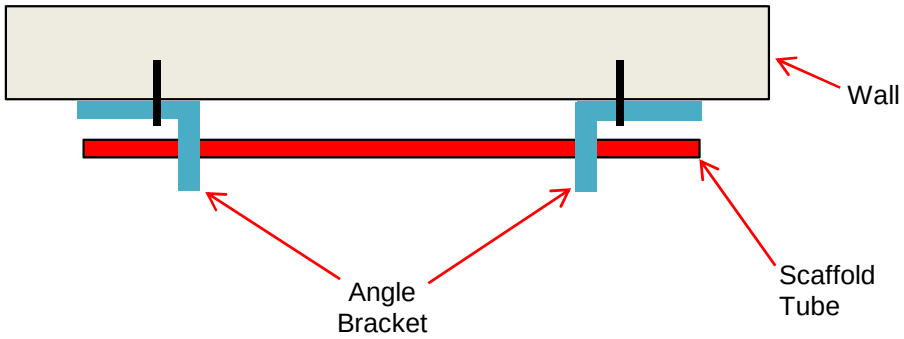
Design assumptions

Bracket to carry max tie load of 8kN

Backet to carry max moment in a scaffold tube (1kNm)

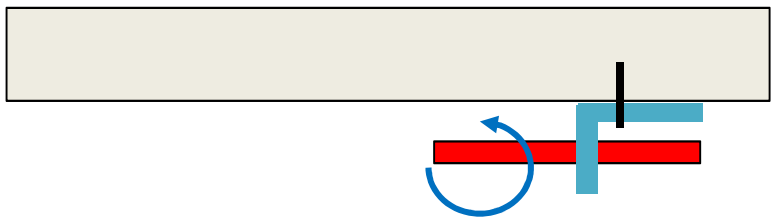
Loading

Angle bracket is to be used as a scaffold tie
this will involve 2No angle brackets anchored to a wall with a scaffold tube spanning between the holes in the bracket, as per the sketch below



Maximum Scaffold Tie Horizontal Load = 8.00 kN

It is conservatively assumed that the full 8.00kN is applied to 1No angle bracket

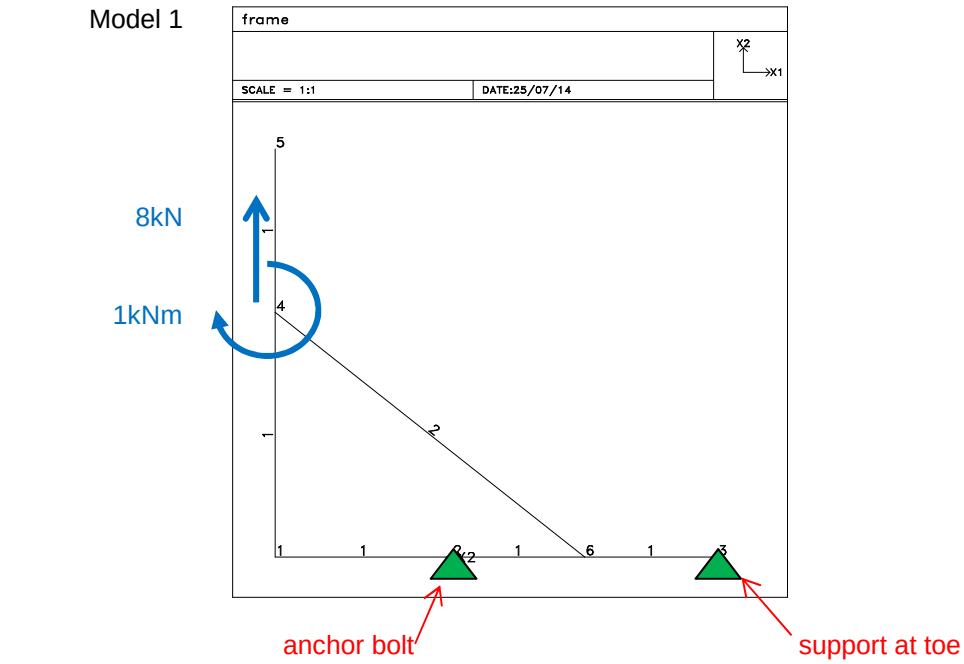


An bending moment of 1kNm is also applied
to allow for maximum allowable moment in a scaffold tube

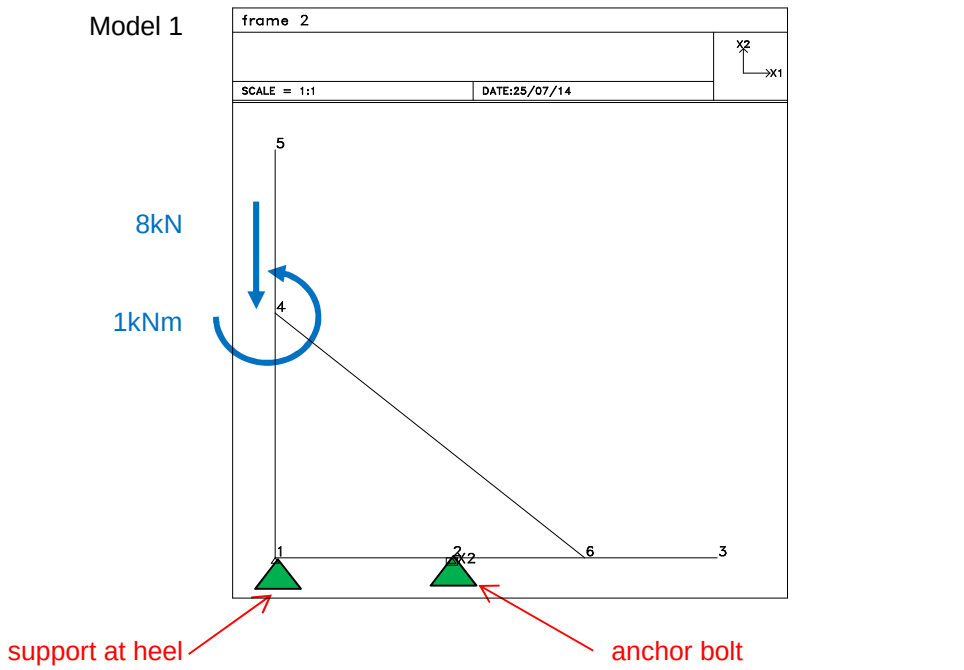
Analysis

two models have been analysed for this bracket to take into account the reversible tie loading

Model 1



Model 1



Results

The results from the STRAP analysis are

Model 1

Angle

Moment	M_E=	2.43	kNm
Shear	V_E=	29.6	kN
Tension	N_{uR}=	18.7	kN
Compression	N_{bR}=	0	kN

Gusset

Moment	M_E=	0.05	kNm
Shear	V_E=	0	kN
Tension	N_{uR}=	0	kN
Compression	N_{bR}=	6.6	kN

Anchor bolt

Tension	N_{uR}=	24.4	kN

Model 2

Angle

Moment	M_E=	1.73	kNm
Shear	V_E=	25.1	kN
Tension	N_{uR}=	0	kN
Compression	N_{bR}=	19.3	kN

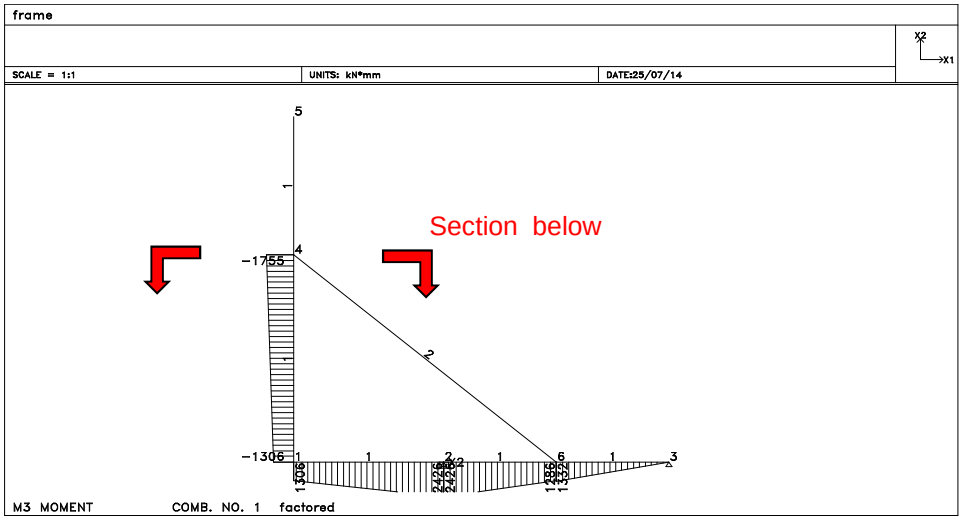
Gusset

Moment	M_E=	0.07	kNm
Shear	V_E=	0	kN
Tension	N_{uR}=	6.7	kN
Compression	N_{bR}=	0	kN

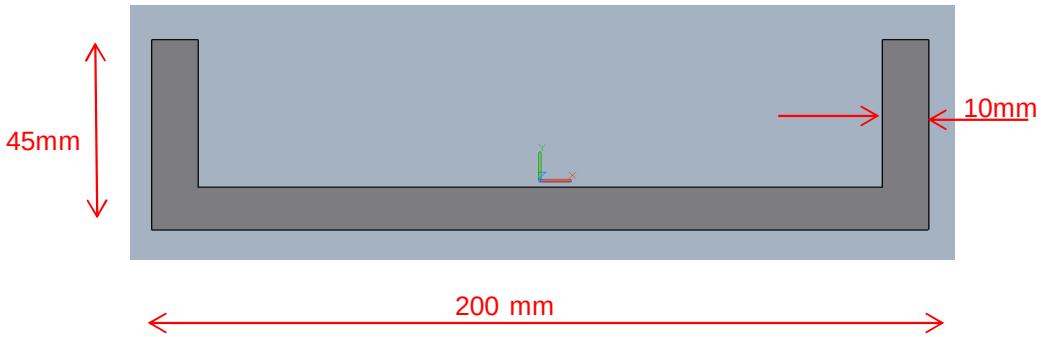
Anchor bolt

Tension	N_{uR}=	16.67	kN

Angle - Layout The max moments occur at the bolts and at the point of application



Angle - Section Section through angle and gussets



A=	2700	mm^2
I=	350625	mm^4
W_{el}=	10261	mm^3

Angle - Results

The max results from the analysis are

Moment	M_E=	2.43	kNm
Shear	V_E=	29.6	kN
Tension	N_{uR}=	18.7	kN
Compression	N_{bR}=	19.3	kN

Angle - Moment capacity to BS EN 1993-1-1

$M_{Ed,x}$= **2.43 kNm**

$M_{cr,x}$= $W_{el}.f_y/\gamma_{m0}$ $W_{el,y}$= 10.26 cm^3

f_y= 275 N/mm^2

γ_{m0}= 1

= 10.26*275/1000

= **2.82 kNm**

> **2.43 kNm** **ok**

Angle -Shear to BS EN 1993-1-1

V_{Ed}= **29.60 kNm**

V_{cr}= $A_v.f_y/sqrt(3)/\gamma_{m0}$

A_v= 2h t
A_v= 2*45*10 mm^2
A_v= 900.00 mm^2
f_y= 275 N/mm^2
γ_{m0}= 1

= 900*275/sqrt(3)/1000
= **142.89 kN**
> **29.60 kN** **ok**

Angle -Tension capacity to BS EN 1993-1-1

N_{Ed}= 18.70 kN

plastic resistance N_{plr}= $A.f_y/\gamma_{m0}$

A= 2,700.00 mm^2
f_y= 275 N/mm^2
γ_{m0}= 1

= 2700*275/1000
= 742.50 kN

ultimate resistance

allowing for 50mm hole for scaffold tube

N_{ur}= $0.9A.f_u/\gamma_{m2}$ $0.9A_{net}$= 0.9*(2400-50*10)
1,710.00 mm^2
f_u= 430 N/mm^2
γ_{m2}= 1.25

= 1710*430/1250
= 588.24 kN

Lesser Value= **588.24 kN**
> **18.70 kN** **ok**

Angle - Compression

$N_{b,Ed}$= **19.30 kN**

$N_{b,Rd}$= X A f_y/γ_{m2}

N_{cr}= $\pi^2 EI/L^2$

= 87581315.91 N

λ^-= $\sqrt{Af_y/N_{cr}}$

= 0.07

φ= $0.5(1+\alpha(\lambda^- -0.2)+\lambda^{-2})$

= 0.50

χ= $1/\varphi+\sqrt{\varphi^2-\lambda^{-2}}$

= 1.00

$N_{b,Rd}$= X A f_y/γ_{m0}

$N_{b,Rd}$= **470.25 kN**

> **19.30 kN** **ok**

χ= $1/\varphi+\sqrt{\varphi^2-\lambda^{-2}}$

φ= $5(1+\alpha(\lambda^- -0.2)+\lambda^{-2}$

λ^-= $\sqrt{A.f_y/N_{cr}}$

α= 0.21 Table 6.1

E= 205000 N/mm^2

I= 350625 mm^4

L= 90 mm

A= 1,710.00 mm^2

f_y= 275 N/mm^2

α= $\sqrt{A.fy/Ncr}$ Table 6.1

Angle - combined

$N_E/N_r+M_E/M_r$= 19.3/483+2.43/2.82

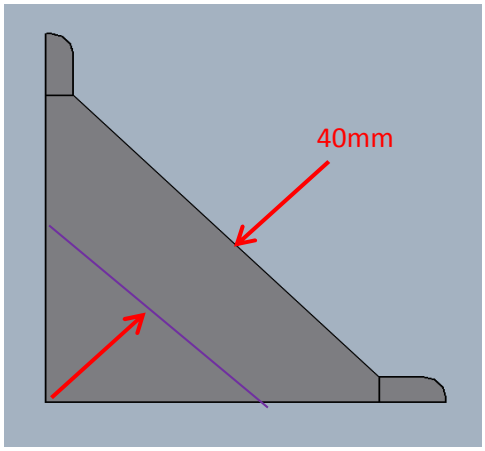
= **0.90**

< **1** **ok**

Gusset - Layout

There are two gussets each of which is carrying half of the analysed axial load

For conservative design assume only one is carrying all of the load and that the gusset width to carry the load is 40mm



Gusset - Section

A=	400	mm^2
Iy=	53333	mm^4
Iz=	3333	mm^4

Gusset - Results

The max results from the analysis are

Gusset

Tension	N_{uR}=	6.7 kN
Compression	N_{bR}=	6.6 kN

Gusset -Tension capacity to BS EN 1993-1-1

N_{Ed}= 6.70 kN

plastic resistance N_{plr}= $A.f_y/\gamma_{m0}$

A= 400.00 mm^2

f_y= 275 N/mm^2

γ_{m0}= 1

= 400*275/1000

= 110.00 kN

ultimate resistance

allowing for 50mm hole for scaffold tube

N_{ur}= $0.9A.f_u/\gamma_{m2}$ $0.9A_{net}$= 0.9*400

= 360.00 mm^2

f_u= 430 N/mm^2

γ_{m2}= 1.25

= 360*430/1250

= 123.84 kN

Lesser Value= **110.00 kN**

> **6.70 kN** **ok**

Gusset - Compression

$N_{b,Ed}$= **6.60 kN**

$N_{b,Rd}$= X A f_y/γ_{m2}

N_{cr}= $\pi^2 EI/L^2$

= 4795896.657 N

λ^-= $\sqrt{Af_y/N_{cr}}$

= 0.14

φ= $0.5(1+\alpha(\lambda^- -0.2)+\lambda^{-2})$

= 0.51

χ= $1/\varphi+\sqrt{\varphi^2-\lambda^{-2}}$

= 1.00

$N_{b,Rd}$= X A f_y/γ_{m0}

$N_{b,Rd}$= **99.00 kN**

> **6.60 kN** **ok**

χ= $1/\varphi+\sqrt{\varphi^2-\lambda^{-2}}$

φ= $5(1+\alpha(\lambda^- -0.2)+\lambda^{-2}$

λ^-= $\sqrt{A.f_y/N_{cr}}$

α= 0.21 Table 6.1

E= 205000 N/mm^2

I= 53333 mm^4

L= 150 mm

A= 360.00 mm^2

f_y= 275 N/mm^2

α= $\sqrt{A.fy/Ncr}$ Table 6.1

Gusset weld

The weld in the end of the gusset carries the axial load in the gusset

Conservatively again assume only a 40mm width of the gusset carries the total load

gusset is welded on one side only so take length as 40mm only

N_E= 6.7 kN

so force per unit length is

$F_{w,Ed}$= N_E/40 N_E= 6700 N
= 6700/40
= **167.50** N/mm

From BSEN 1993-1-8 4.5.3.3

Fillet weld resistance is, assuming 5mm weld

f_{vw}= f_u/sqrt(3)/$\beta\gamma_{M2}$ f_u= 275 N/mm2
β= 0.85 Table 4.1
γ_{M2}= 1.25
= 275/sqrt(3)/(0.85*1.25)
= 149.43 N/mm

$F_{w,Rd}$= f_{vw}.a f_{vw}= 149.43 N/mm2
a= thoat width
= 0.7*5
= 3.50 mm
= 149.43*3.5
= **523.01 N/mm**
> **167.50** **ok**

Anchor bolts

max axial loads in bolts is

Tension N_E= 24.4 kN in two bolts
= **12.2 kN in one bolt**

from HILTI design HKD M16/65 anchor has a resistance in tension of

N_R= **17.6 kN**
> **12.20** **ok**

Summary

Angle is 150 by 150 by 10 EA S275 180mm long

Gusset plates are 125 by 125 by 10 S275 with 10mm chamfer

Section can carry applied axial load of 8kN and 1kNm bending moment