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DESIGN CALCULATIONS

Project: ACCESS SCAFFOLD

Site: 16-27 JOHN DRINKWATER

Client: WATES

Project Number: 15257-ESS-0051-CAL REV 02

Date: 25/09/2023

Pages: 13

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Technical Information

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Regulations

The Working at Height Regulations 2005
 The Construction (Design and Management) Regulations 2015

British Standards

BS 5975: 2019	Code of practice for temporary works procedures and the permissible stress design of false work
BS 8118 Part 1: 1991	Structural Use of Aluminium - Code of Practice for Design
BS EN 12810-1:2003	Façade scaffolds made of prefabricated components - products specifications
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 1991 Part 1-4:2005	Eurocode 1: Actions on structures - General Actions - Wind Actions
BS EN 39: 2001	Loose steel tubes for tube and coupler scaffolds - Technical delivery conditions
BS EN 1991-1-3:2003	Eurocode 1: Actions on structures - General Actions - Snow Load
EN 74-1	Couplers, spigots, and baseplates for use in false works and scaffolds

Current Revisions of Relevant Guides

CG6	Scaffold Design
SG4	The use of Fall Arrest Equipment Wlist Erecting, Altering & Dismantling Scaffolding
TG4	Anchoring systems for scaffolding
TG20	NASC Technical Guidance on the use of BS EN 12811-1
TG09	Design and construction of temporary roofs
TG14	Supplementary Couplers and Check Couplers
TG16	Anchoring to the ground

Safe working loads and weights: B.M. (KNm) Shear (kN) Weight (from data sheets)

	B.M. (KNm)	Shear (kN)	Weight
Steel scaffold tube (as new)	1.12	25.90	4.37 kg/m
Alu. Scaffold tube	1.33	25.50	1.66 kg/m
305 Steel Ladder Beam	10.40	18.00	11.90 kg/m
450 Deep Aluminium Beam	18.50	12.20	5.10 kg/m
750 Deep Alloy X-Beam	35.00	35.00	6.50 kg/m
1280 Dessa Asterix HD Aluminium Beam	102.76	42.10	10.90 kg/m
38mm thick scaffold board	0.48		6.00 kg/m
50mm thick scaffold board	0.80		8.00 kg/m

Safe working loads for couplers prEN-74-1: Slip (kN)

Right-angle coupler Class A	6.06	1.25 kg
Right-angle coupler Class B	9.09	1.25 kg
Swivel coupler Class A	6.06	1.25 kg
Swivel coupler Class B	9.09	1.25 kg
Parallell coupler Class B	9.09	1.25 kg
SK coupler (in pairs along RSJ)	10.00	1.25 kg
SK coupler (in pairs along tube)	6.50	1.25 kg
SK coupler (hanging in pairs)	30.00	1.25 kg
	15.00	(on leading coupler)



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Loading Conditions

1.0 Actions

1.1 Permanent loads

The permanent loads are presented as self weight of scaffold structure including tubes, beams, fittings, boards etc.

1.2 Variable loads

1.2.1 Service load

Load class of scaffold = 2

Maximum imposed load on access scaffold must not exceed: 1.50 kN/m²

Maximum imposed load on inside board(s) must not exceed: 0.75 kN/m²

Maximum imposed load on birdcage working platform must not exceed: 1.50 kN/m²

For birdcage structures service load to be imposed on the area of 6.0 m²

Max imposed load on remaining protection deck area must not exceed: 0.75 kN/m²

Only one 100% loaded and one 50% loaded working platforms may be in use at any one time.

Concentrated load F1 = 1.50 kN

On the area = 0.5m x 0.5m

Concentrated load F2 = 1.00 kN

On the area = 0.2m x 0.2m

1.2.2 Horizontal loads

In case of absence of wind consider 2.5% of service load imposed on the working lifts or 0.3kN, whichever is greater.

1.2.3 Horizontal loads on the handrail

Horizontal point load on the handrail = 0.30 kN

1.2.4 Loads on the toeboard

Point load on the toeboard = 0.2 kN

1.2.5 Wind Loads See Section 2.0 Peak Velocity pressure = 0.55 kN/m²

1.2.6 Snow Loads See Section 3.0 Snow loading = N/A kN/m²

1.2.7 Buffeting Loads See Section 4.1 On vertical surfaces = N/A kN/m²

See Section 4.2 On horizontal surfaces = N/A kN/m²

1.3 Accidental loads

Downward load on the handrail = 1.25 kN

Design Calculations

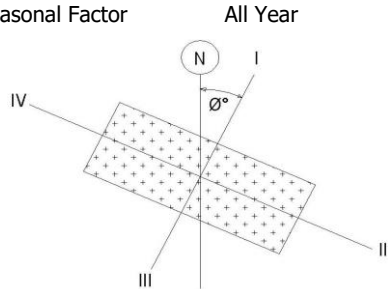
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2.0 Wind Loading (BS EN 1991-1-4)

Height of scaffold	$h =$	10.00 m
Height from ground level to top of the scaffold	$z =$	10.00 m
Fundamental basic wind velocity before altitude correction	$V_{b, map} =$	21.50 m/s
Site altitude	$A =$	30.00 m
Altitude factor	$C_{alt} =$	1.030
Duration of scaffold	$=$	>12 months
Probability factor	$C_{prob} =$	1.000
The fundamental basic wind velocity	$V_{b, 0} =$	22.15 m/s
Seasonal Factor	$C_{season} =$	1.00



		I	II	III	IV
Wind Direction	deg	5	95	185	275
Direction factor	c_{dir}	1.000	1.000	1.000	1.000
Basic wind velocity (m/s)	$v_b =$	22.15	22.15	22.15	22.15
Basic velocity pressure (kN/m ²)	$q_b =$	0.30	0.30	0.30	0.30
Terrain		town	town	town	town
Ave. height of nearby buildings (m)	$h_{ave} =$	12.00	12.00	12.00	12.00
Average upwind spacing (m)	$x =$	80.00	80.00	80.00	80.00
Displacement height (m)	$h_{dis} =$	0	0	0	0
Effective height (m)	$z - h_{dis} =$	10	10	10	10
Distance to sea (km)		150	80	70	90
Exposure factor	$c_e(z) =$	2.33	2.35	2.36	2.34
Distance inside town (km)		15	15	30	35
Exposure correction factor	$c_{e,T} =$	0.79	0.79	0.77	0.77
Peak Velocity pressure (kN/m ²)	$q_p(z) =$	0.55	0.55	0.55	0.54



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2.1 Force and external pressure coefficients

Scaffolding components

$C_{f\ t/boards} = 2.00$ For toeboards

$C_{f\ tube} = 1.20$ For tube

Side sheeting

$C_{pe\ windward} = 0.80$ For sheeting, windward (Zone D)

$C_{pe\ leeward} = 0.70$ For sheeting, leeward (Zone E)

$C_{pe\ wall} = 1.30$ For sheeting, windward + leeward

$C_{f\ s/boards} = 1.80$ For signboards

2.2 Wind forces per 1 m² of upwind area

$$F_w = C_s C_d \times C_{f\ (pe)} \times q_p(z)$$

$C_s C_d = 1.00$ For all elements

Scaffolding components

$F_{t/boards} = 1.11\ kN/m^2$ For toeboards

$F_{tube} = 0.67\ kN/m^2$ For tube

Side sheeting

$F_{windward} = 0.44\ kN/m^2$ For sheeting, windward (Zone D)

$F_{leeward} = 0.39\ kN/m^2$ For sheeting, leeward (Zone E)

$F_{wall} = 0.72\ kN/m^2$ For sheeting, windward + leeward

$F_{s/boards} = 1.00\ kN/m^2$ For signboards

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

N/A

4.0 Buffeting Load (BS EN 1991-2:2003 (E))

N/A



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5.0 Scaffolding Components

Tube and Fitting Components

5.1 Boards

$$\text{Width of standard scaffold board } (L_w) = 0.225 \text{ m}$$

$$\text{Maximum transom centres to working platform } (t_{cc}) = 1.00 \text{ m max}$$

$$\text{Self weight of 38mm thick timber scaffold board} = 0.25 \text{ kN/m}^2$$

$$\text{Total load on working platform } (W) = 1.75 \text{ kN/m}^2$$

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

$$W_b = 0.39 \text{ kN/m}$$

$$\text{BM in board} = W_b L L / 8$$

$$\text{where } L = t_{cc}$$

$$\text{BM} = 0.05 \text{ kNm}$$

$$\text{Permissible BM in 38mm thick timber scaffold board (TG20:13)} = 0.475 \text{ kNm}$$

$$0.475 > 0.05 \text{ therefore OK}$$

5.2 Transoms

$$\text{Maximum transom span under working platform } (L_t) = 1.00 \text{ m}$$

$$\text{Load per transom span } (W_t) = t_{cc} \times W$$

$$W_t = 1.75 \text{ kN/m}$$

$$\text{BM in transom} = W_t L L_t / 8$$

$$= 0.22 \text{ kNm}$$

$$\text{Permissible BM in Type 4 steel tube - as new (BS1139-1-1:1990 - TG20:13)} = 1.12 \text{ kNm}$$

$$1.12 > 0.22 \text{ therefore OK}$$

5.3 Ledgers

$$\text{Maximum ledger span under working platform } (L_L) = 2.00 \text{ m}$$

$$\text{Number of transoms per ledger span } (T_{no}) = 1.00 \text{ No}$$

Considering the equally distributed transoms

$$\text{Load per ledger span } (W_L) = L_L / 2 \times t_{cc} \times W \times T_{no}$$

$$W_L = 0.88 \text{ kN}$$

$$\text{BM in ledger} = W_L * L_L / 4$$

$$= 0.44 \text{ kNm}$$

$$\text{Permissible BM in Type 4 steel tube - as new (BS1139-1-1:1990 - TG20:13)} = 1.12 \text{ kNm}$$

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 $1.12 > 0.44$ therefore **OK**

Connection capacity between standard and ledger is limited by the slip capacity of the couplers used:

1 no. Class A Right-angle couplers at 6.06 kN ea. = 6.06 kN

 $6.06 > 1.75$ therefore **OK**

5.4 Ledgers (with inside board)

Maximum ledger span under working platform (L) = 2.00 m

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

Maximum transom centres to working platform (t_{cc}) = 1.00 m

Number of transoms per ledger span (Tno) = 1.00 No

Effective platform width provided by inside board (L_{ib}) = 0.68 m

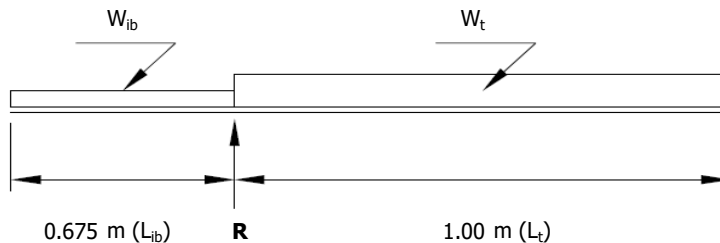
Worst load case occurs with a single transom located at mid-span:

Reaction **R** at inside ledger:

load on transom from main platform: $W_t = 1.75$ kN

UDL on inside board = 0.75 kN/m²

Load on transom from inside board: $W_{ib} = (\text{UDL (inside)} \times L_{ib} \times t_{cc}) + \text{swt board}$
 $= 0.68$ kN


 $R = ((W_t \times L_t / 2) + (W_{ib} \times [L_t + L_{ib} / 2])) / L_t = 1.78$ kN

Load per ledger span (W_L) = $R \times Tno$

Total load per ledger span $WL = 1.78$ kN

BM in ledger = $WL * LL / 4$

= 0.89 kNm

Permissible BM in Type 4 steel tube - as new (BS1139-1-1:1990 - TG20:13) = 1.12 kNm

 $1.12 > 0.89$ therefore **OK**



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Intermediate Standards - Beam Puncheons

Number of lifts (including foot lift) =	1.00 No
Average lift height =	2.00 m
Average Adjacent Bays size =	2.00 m
Scaffold width =	1.00 m
Transom centres =	1.00 m
Number of Inside boards =	1.00 No
Number of boarded lifts =	1.00 No
Number of lifts with inside board =	1.00 No
Number of 100% loaded lifts =	1.00 No
Number of 50% loaded lifts =	0.00 No

Axial load of scaffold per inside standard

Standards	1.0 no.	x	2.30 m	=	2.30 m
Ledgers	1.0 no.	x	2.00 m	=	2.00 m
Transoms (with IB)	2.0 no.	x	0.73 m	=	1.45 m
Transoms (without IB)	0.0 no.	x	0.50 m	=	0.00 m
Transoms (structural)	0.0 no.	x	0.50 m	=	0.00 m
Ledger bracing	0.0 no.	x	1.12 m	=	0.00 m
Total					5.75 m
Self weight of scaffold tube =	5.75 m	x	4.37 kg/m	=	25.13 kg
Fittings	6 no.	x	1.40 kg each	=	8.40 kg
			self weight of scaffold =		33.53 kg
				=	0.33 kN
Main working platform	L_E 2.00 m	x	L_W 0.50 m	=	1.00 m ²
		1	No of boarded lifts =		1.00 m ²
Inside board area	2.00 m	x	0.23 m	=	0.45 m ²
		1	No of lifts with IB =		0.45 m ²
Self weight of boards =	1.45 m ²	x	0.25 kN/m ²	=	0.36 kN
			Total self weight of scaffold per inside standard =		0.69 kN
Imposed load 100%	1.00 m ²	x	1.50 kN/m ²	=	1.50 kN
Imposed load 50%	0.00 m ²	x	0.75 kN/m ²	=	0.00 kN
Imposed load on IB 100%	0.45 m ²	x	0.75 kN/m ²	=	0.34 kN
Imposed load on IB 50%	0.00 m ²	x	0.00 kN/m ²	=	0.00 kN



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Total self weight and imposed load per inside standard = **2.53 kN**

Axial load of scaffold per outside standard

Standards	1.0 no.	x	3.30 m	=	3.30 m
Ledgers	1.0 no.	x	2.00 m	=	2.00 m
Transoms (with IB)	2.0 no.	x	0.50 m	=	1.00 m
Transoms (without IB)	0.0 no.	x	0.50 m	=	0.00 m
Transoms (structural)	0.0 no.	x	0.50 m	=	0.00 m
Handrails Outside	2.0 no.	x	2.00 m	=	4.00 m
Handrails Intermediate	0.0 no.	x	2.00 m	=	0.00 m
Ledger bracing	0.0 no.	x	1.12 m	=	0.00 m
Face bracing	0.0 no.	x	1.41 m	=	0.00 m

Total 10.30 m

Self weight of scaffold tube = 10.30 m x 4.37 kg/m = 45.01 kg

Fittings 8 no. x 1.40 kg each = 11.20 kg

self weight of scaffold = 56.21 kg

= 0.55 kN

Main working platform L_E 2.00 m x L_W 0.50 m = 1.00 m²

Toeboard 2.00 m x 0.23 m = 0.45 m²

1 No of boarded lifts = 1.45 m²

Self weight of boards = 1.45 m² x 0.25 kN/m² = 0.36 kN

Total self weight of scaffold per outside standard = 0.91 kN

Imposed load 100% 1.00 m² x 1.50 kN/m² = 1.50 kN

Imposed load 50% 0.00 m² x 0.75 kN/m² = 0.00 kN

Total self weight and imposed load per outside standard = **2.41 kN**

Effective length of steel scaffold tube BS EN 39 = 2000 mm

The axial load capacity (TG20:13) = 29.02 kN

Maximum axial load on standard = **2.53 kN**

29.02 > 2.53 therefore **OK**



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5.5 450 Deep Layher Alloy Beam

Effective beam length = 30.00 m

Maximum beam span = 9.70 m

Beam centres = 1.00 m

Width of deck imposed at each beam = 0.500 m

Self weight of beam per 1 m run

Top chord lacing	1 no.	x	0.50 m	=	0.50 m
Bottom chord lacing	0.5 no.	x	0.50 m	=	0.25 m
Plan bracing	0.5 no.	x	1.12 m	=	0.56 m
Diagonal bracing	0.5 no.	x	0.56 m	=	0.28 m

Total 1.59 m

Self weight of scaffold = 1.59 m x 4.37 kg/m = 6.94 kg

Fittings	2.5 no.	x	1.40 kg each	=	3.50 kg
Beam	1 m	x	5.10 kg/1m run	=	5.10 kg

Total self weight of scaffold = 15.54 kg/1m run

= **0.15 kN/1m run**

	L_E		W_E		
Working platform	1.00 m	x	0.50 m	=	0.50 m ² /1m run

Self weight of boards: 0.50 m² x 0.25 kN/m² = **0.13 kN/1m run**

Imposed load 0.50 m² x 0.75 kN/m² = **0.38 kN/1m run**

Total UDL on beam = **0.65 kN/1m run**

Point load from main independent = 2.53 kN

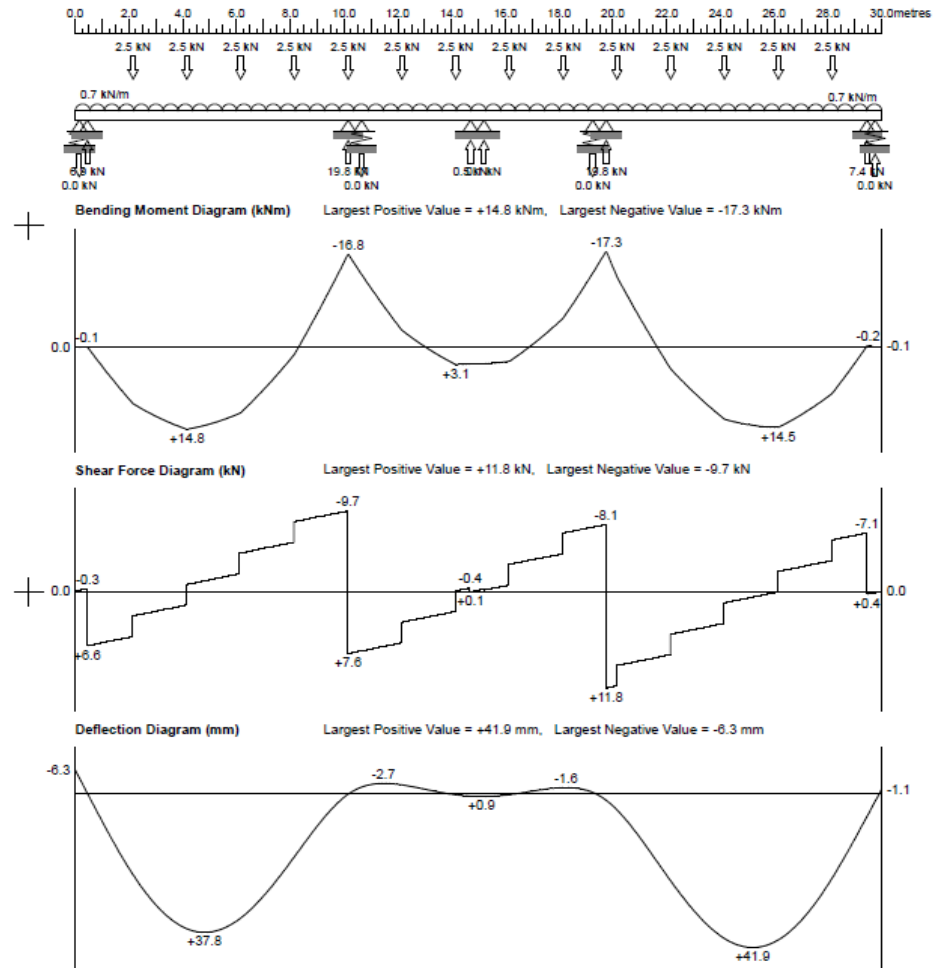
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Permissible BM in 450 deep alloy beam =	18.50 kNm			
2 No =	37.00 kNm	>	17.30 kNm	OK
Permissible shear in 450 deep alloy beam =	12.20 kN			
2 No =	24.40 kN	>	11.80 kN	OK
Allowable deflection of beam = L/200 =	48.5 mm	>	41.90 mm	OK

Support Reactions:

Standard:

Maximum support reaction into support standard = 19.80 kN

Connection capacity between standard and beam is limited by the slip capacity of the couplers used:

4 no. Class A Right-angle couplers at 6.06 kN ea. =	24.24 kN			
24.24	>	19.80	therefore	OK

5.7 Ground Bearing pressure

Total vertical load on the most loaded standard = 19.80 kN

Sole plate length = 0.45 m

Sole plate width = 0.225 m

Minimum sole pad area under beam support standard = 0.101 m²

therefore, ground bearing pressure under sole pad = 195.56 kN/m²

Effective length of steel scaffold tube BS EN 39 = 1500 mm

The axial load capacity (TG20:13) = 42.04 kN

Maximum axial load on standard = **19.80 kN**

42.04 > 19.80 therefore **OK**

6.0 Stability

Considering a typical 2000mm bay of scaffold:

Sheeting area broadside to wind:

Sheeting area	L_E	x	H_E	=	12.00 m ²
	4.00 m		3.00 m		

Wind force on sheeting area (leeward) = 0.39 kN/m²

Horizontal wind induced area on sheeting area = 4.66 kN



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6.3 Ties

Tension applied per tie arrangement= 4.66 kN
Shear applied per tie arrangement= 0.00 kN
No anchors= 1.00
Tension applied in one single anchor= 4.66 kN
Shear applied in one single anchor= 0.00 kN

Type of anchors: Hook Tie with Nylon Plug

Base material: Concrete

Capacity of anchors from data sheet:

Safe working load. Tension= 6.10 kN
6.10 > 4.66 therefore **OK**

Tie load testing. Pull out test:

Proof test load (F.O.S 1.25 : 1) ≥ 5.82 kN
Preliminary test load (F.O.S 2 : 1) ≥ 9.32 kN

7.0 Rigidity

The rigidity of the scaffold is maintained by the bracing in each bay:

Total horizontal wind load = 4.66 kN
Horizontal wind load is maintained by bracing = 1 No
Maximum horizontal wind load in a single first lift level brace = 4.66 kN
Height of lift = 2.00 m
Length (Depth) of bay = 1.00 m
Length of brace = 2.24 m
Resultant axial load in brace = $(2.24/1) \times 4.66$
= 10.42 kN

Axial brace capacity is limited by the slip capacity of the couplers used:

1 no. Class B Right-angle couplers at 9.09 kN ea. = 9.09 kN
Factor on resistances for wind induced loading = 1.25
therefore, resulting axial brace capacity under WILL = 11.36 kN
11.36 > 10.42 therefore **OK**

End of Calculations