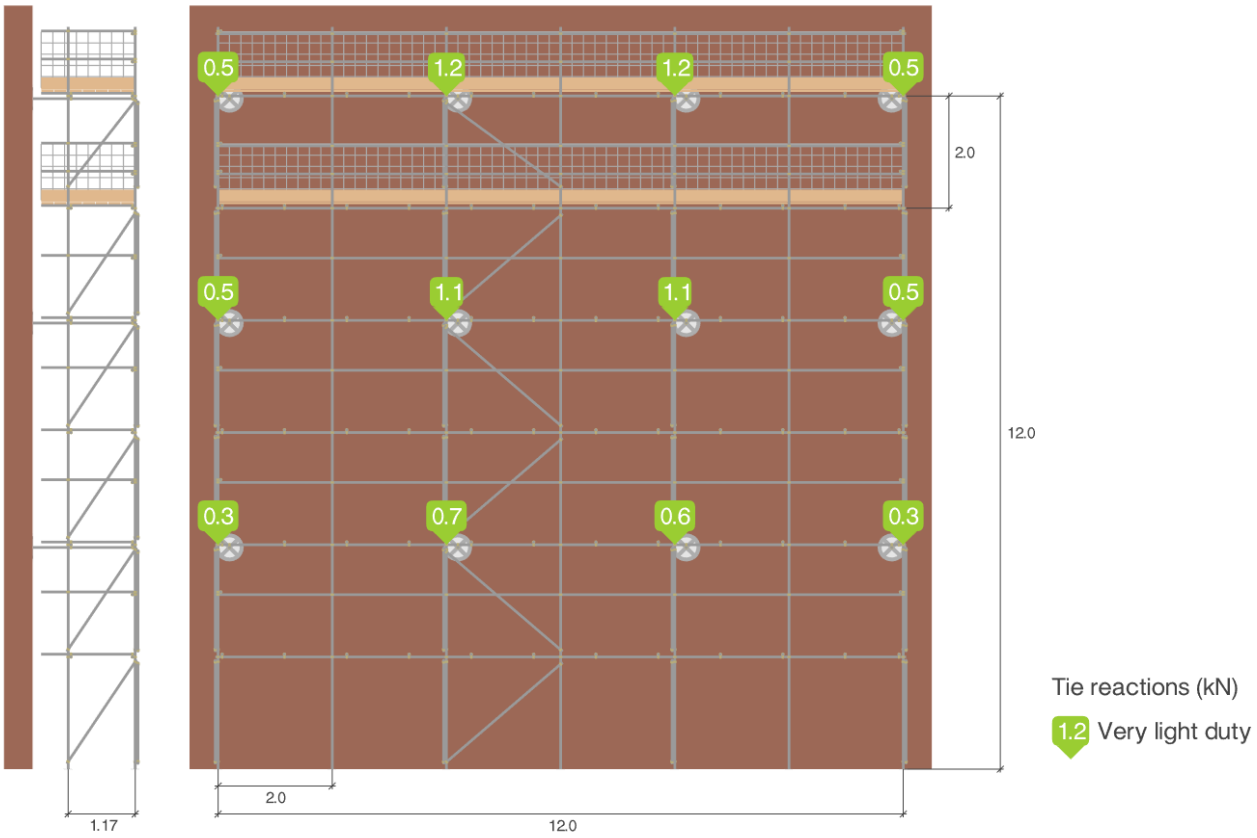
Independent scaffolding tie duty

For tube and fitting scaffolding, in accordance with BS EN 12811-1:2003 and NASC TG20:13.

ℹ This calculation should be read in conjunction with the wind factor and leg load calculation reports.



Site location

Description	Value
Site address	East Overcliff Drive, E Overcliff Dr, Bournemouth BH1, UK
TG20:13 wind factor, $S_{TG20:13}$	26.6
Peak velocity pressure at 13.00 m, $q_{p(z = 13.00m)}$	0.888 kN/m²

Scaffold dimensions

Description	Value
Number of boarded lifts, n_b	2
Number of unboarded lifts, n_u	4
Maximum lift height, H_{lift}	2.00 m
Maximum bay length, L_{bay}	2.00 m
Number of main boards wide, n_m	5
Number of inside boards, n_i	2

Edge protection

Description	Value
Guard rails at boarded lifts, $n_{gr,b}$	2
Guard rails at unboarded lifts, $n_{gr,u}$	1
Inner guard rails at boarded lifts	None
Inner guard rails at unboarded lifts	None
Inner toe boards	None

Scaffold configuration

Description	Value
Cladding	Brick guards
Facade permeability [1]	Impermeable
Tie pattern	TG20:13 A
Structural transoms	None

[1] No significant openings.

In-service wind loading

Site coefficient with an impermeable facade	$c_s = 0.25$
Aerodynamic force coefficient for tubes	$c_{f,t} = 1.2$
Aerodynamic force coefficient (normal) for toe boards	$c_{f,b} = 1.3$
Aerodynamic force coefficient (normal) for brick guards	$c_{f,bg} = 0.177$
In-service wind peak velocity pressure	$q_{p,i} = 0.200$ kN/m²

In-service wind loads on the standard pairs

Tube diameter	$d_t = 0.048$ m
In-service unit wind load on tubes	$F_{t,1,i} = q_{p,i} \cdot c_s \cdot c_{f,t} \cdot d_t = 0.200 \cdot 0.25 \cdot 1.2 \cdot 0.048 = 0.003$ kN/m
In-service wind load per standard pair	$F_{s,i} = 2 \cdot F_{t,1,i} = 2 \cdot 0.003 = 0.006$ kN/m
In-service wind load per ledger-braced standard pair	$F_{s,lb,i} = F_{s,i} + F_{t,1,i} = 0.006 + 0.003 = 0.009$ kN/m

In-service wind loads on the ledger pairs

Number of ledger lengths per bay	$N_l = 2$
In-service wind load per lift on tubes at boarded lifts	$F_{t,b,i} = (N_l + n_{gr,b}) \cdot F_{t,1,i} = (2 + 2) \cdot 0.003 = 0.012$ kN/m
In-service wind load per lift on tubes at unboarded lifts	$F_{t,u,i} = (N_l + n_{gr,u}) \cdot F_{t,1,i} = (2 + 1) \cdot 0.003 = 0.009$ kN/m
Reference height for materials at in-service working lifts, TG20:13 Design Guide Table 4.3	$H_{r,m} = 0.438$ m
Wind load per working lift on toe board and materials	$F_{wm,i} = q_{p,i} \cdot c_s \cdot c_{f,b} \cdot H_{r,m} = 0.200 \cdot 0.25 \cdot 1.3 \cdot 0.438 = 0.028$ kN/m
Brick guard height	$H_{bg} = 1.0$ m
Brick guard reference height at working lifts	$H_{bg,w} = H_{bg} - H_{r,m} = 1.0 - 0.438 = 0.562$ m
In-service wind load per working lift on brick guards	$F_{bg,w,i} = q_{p,i} \cdot c_s \cdot H_{bg,w} \cdot c_{f,bg} = 0.200 \cdot 0.25 \cdot 0.562 \cdot 0.177 = 0.005$ kN/m
In-service wind load per working lift ledger pair	$F_{l,w,i} = F_{t,b,i} + F_{wm,i} + F_{bg,w,i} = 0.012 + 0.028 + 0.005 = 0.045$ kN/m
In-service wind load per unboarded lift ledger pair	$F_{l,u,i} = F_{t,u,i} = 0.009$ kN/m

Out-of-service wind loading

Out-of-service wind loads on the standard pairs

Out-of-service unit wind load on tubes	$F_{t,1,o} = q_{p(z = 13.00m)} \cdot c_s \cdot c_{f,t} \cdot d_t = 0.888 \cdot 0.25 \cdot 1.2 \cdot 0.048 = 0.013$ kN/m
Out-of-service wind load per standard pair	$F_{s,o} = 2 \cdot F_{t,1,o} = 2 \cdot 0.013 = 0.026$ kN/m
Out-of-service wind load per ledger-braced standard pair	$F_{s,lb,o} = F_{s,o} + F_{t,1,o} = 0.026 + 0.013 = 0.039$ kN/m

Out-of-service wind loads on the ledger pairs

Out-of-service wind load per lift on tubes at boarded lifts	$F_{t,b,o} = (N_l + n_{gr,b}) \cdot F_{t,1,o} = (2 + 2) \cdot 0.013 = 0.051$ kN/m
Out-of-service wind load per lift on tubes at unboarded lifts	$F_{t,u,o} = (N_l + n_{gr,u}) \cdot F_{t,1,o} = (2 + 1) \cdot 0.013 = 0.039$ kN/m
Toe board height	$H_{tb} = 0.225$ m
Board thickness	$t_b = 0.038$ m
Out-of-service wind load per lift on toe board and platform edge	$F_{b,o} = q_{p(z = 13.00m)} \cdot c_s \cdot c_{f,b} \cdot (H_{tb} + t_b) = 0.888 \cdot 0.25 \cdot 1.3 \cdot (0.225 + 0.038) = 0.076$ kN/m

Brick guard reference height at boarded lifts	$H_{bg,b} = H_{bg} - H_{tb} = 1.0 - 0.225 = 0.775$ m
Out-of-service wind load per boarded lift on brick guards	$F_{bg,b,o} = q_{p(z = 13.00m)} \cdot c_s \cdot H_{bg,b} \cdot c_{f,bg} = 0.888 \cdot 0.25 \cdot 0.775 \cdot 0.177 = 0.030$ kN/m
Out-of-service wind load per boarded lift ledger pair	$F_{l,b,o} = F_{t,b,o} + F_{b,o} + F_{bg,b,o} = 0.051 + 0.076 + 0.030 = 0.158$ kN/m
Out-of-service wind load per unboarded lift ledger pair	$F_{l,u,o} = F_{t,u,o} = 0.039$ kN/m

Member properties for 2D grillage analysis

Type 4 steel tube section area	$A_{g,t} = 5.57$ cm²
Type 4 steel tube moment of inertia	$I_{x,t} = 13.77$ cm⁴
Ledger pair moment of inertia	$I_{y,lp} = 2 \cdot I_{x,t} = 2 \cdot 13.77 = 27.54$ cm⁴
Empirical allowance for coupler flexibility and eccentricity	$c_g = 75$
Distance between standards normal to the facade	$W_{sp} = W_m + 2 \cdot d_t = 1.115 + 2 \cdot 0.048 = 1.211$ m
Standard pair moment of inertia	$I_{y,sp} = 2 \cdot I_{x,t} = 2 \cdot 13.77 = 27.54$ cm⁴
Ledger-braced standard pair moment of inertia	$I_{y,sp,lb} = 2 \cdot \left(I_{x,t} + \frac{A_{g,t} \cdot (W_{sp} \cdot 100)^2}{4} \right) \cdot \frac{1}{c_g} = 2 \cdot \left(13.77 + \frac{5.57 \cdot (1.211 \cdot 100)^2}{4} \right) \cdot \frac{1}{75}$ $= 544.90$ cm⁴

Structural analysis

Analysis approach

The analytical model for out-of-plane loading is a 2D grillage frame in the vertical plane merging the stiffnesses of the inner and outer ledgers and standards. Pairs of unbraced ledgers and standards are represented in the 2D model as equivalent members having twice the stiffness of the actual single members. Pairs of ledger braced standards are represented in the 2D model as equivalent single members with stiffness based on the idealised lattice girder with a reduction factor applied to allow for the actual stiffness of the bracing couplers and typical permissible eccentricity relative to the node points. The reduction factor was established by calibration of simplified models against accurate 3D analysis of braced bays and amounts to 1 / 75.

The equivalent grillage members representing the pairs of ledgers and standards are modelled as continuous members at the internal joints in the stiffness analysis, as if they constituted a grillage frame with rigid joints. They are modelled as discontinuous (pinned) to the orthogonal members at the outer joints. For the relevant types of loads, this idealisation gives a satisfactory correlation with the 3D analysis developed for TG20:13 which allowed for the finite stiffness of right angle couplers and other 3D effects.

The guard rails are not included in the stiffness analysis but in the case of unclad scaffolds their wind loads are added to the wind loads on the ledgers as an approximation for the tie loads analysis. As an exception, if the scaffold is clad with sheeting or debris netting the guard rails at the top lift are included as members in the stiffness analysis. The facade bracing members are considered to be pinned to the nodes at the ledger - standard intersections.

The ties and foundations are modelled as pinned supports.

The grillage is subjected to three load categories all applied out-of-plane:

1. Notional loads of 0.3 kN applied to the internal nodes at working lifts and 0.15 kN applied at end nodes as required by BS EN 12811-1 clause 6.2.3.

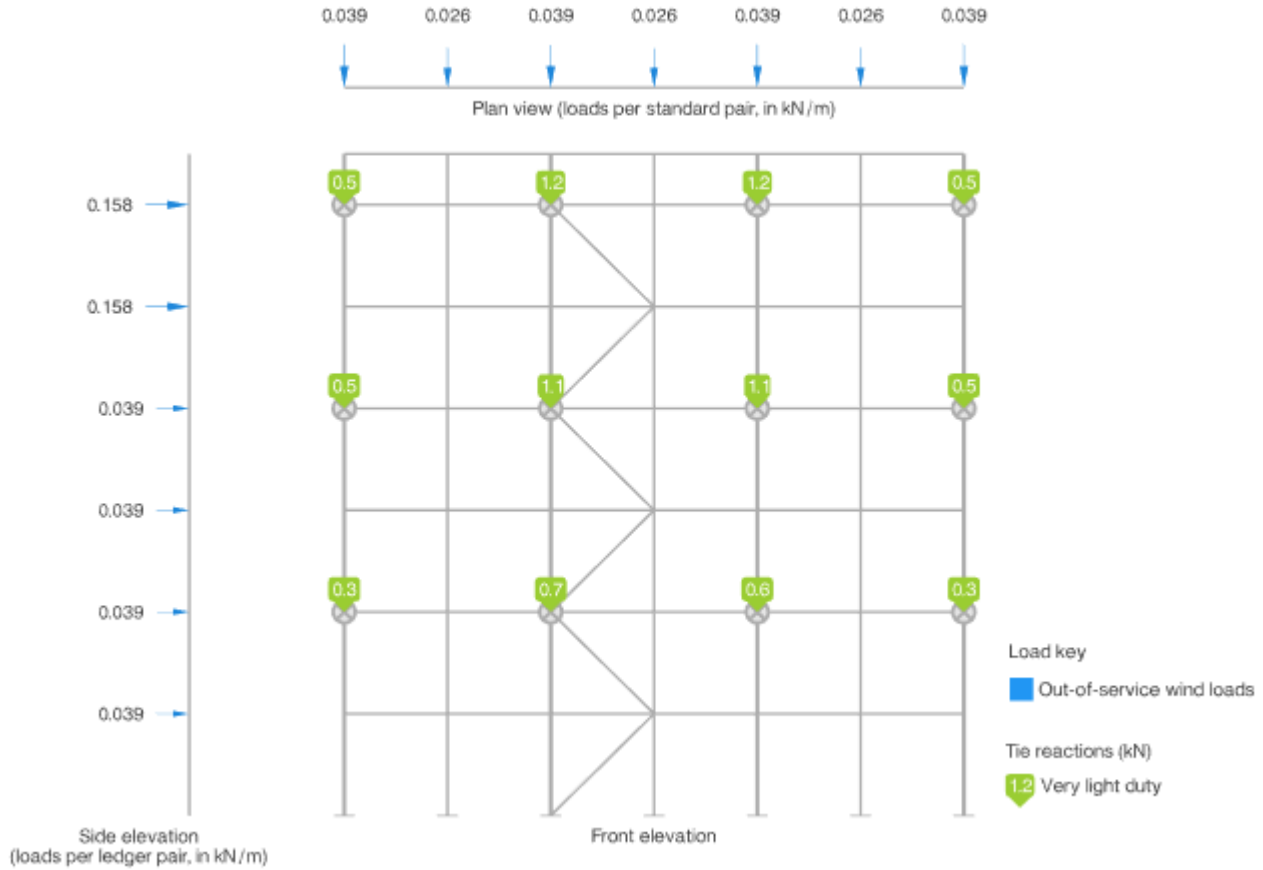
2. Working wind loads applied to the members or cladding based on a peak velocity pressure of 0.2 kN/m².

3. Out-of-service wind loads applied to the members or cladding based on the peak velocity pressure calculated for the site exposure.

All the above idealisations and approximations made to reduce complexity for 2D structural analysis have been validated against examples taken from the more accurate 3D analyses carried out during the development of TG20:13.

Horizontal loads normal to the facade

Load description	In-service	Out-of-service	Unit
Notional horizontal load per working bay	0.300	-	kN
Wind load per standard pair	0.006	0.026	kN/m
Wind load per ledger-braced standard pair	0.009	0.039	kN/m
Wind load per working lift ledger pair	0.045	0.158	kN/m
Wind load per unboarded lift ledger pair	0.009	0.039	kN/m
Wind load on facade bracing	0.003	0.013	kN/m



The analytical model is shown for the load combination which produces the maximum tie duty: 3 - Out-of-service wind loads.

Analysis results

No.	Load combination	Maximum tie duty (kN)
1	Notional horizontal loads	0.90
2	In-service wind loads	0.32
3	Out-of-service wind loads	1.18

Results summary

Description	Value
Maximum tie duty	1.18 kN
TG20:13 tie duty classification	Very light duty (≤ 2.7 kN)

i The capacity of the scaffold ties and the building fabric must be at least 1.18 kN. Guidance for determining the tie capacity is provided in TG20:13 Operational Guide section 7.10.