OUR TOWN HALL PROJECT

Lyndon SGB BY BRANDSAFWAY

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PROJECT:

Customer:	Lendlease
Project location:	OTH, Manchester Town Hall
Project name:	Albert Square, Manchester
Scaffold type:	Freestanding access scaffold

Design Engineer:

Date:

27-05-2021

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1. Introduction

For the purpose of the repair, restoration and carefully considered alteration of the Albert Memorial. a freestanding access scaffold is designed.

The design, is for a working scaffold with:
- Maximum working load of 3kN/m², max 1 level is loaded.
- Loading decks with a maximum loading of 5kN/m², max 1 deck loaded.
- Several lifting locations with a maximum lift of 500kg, only use one at the time

These calculations are for: Tube and fitting.

The scaffold has the following dimensions:
Width: 15,4 [m]
Length: 17,3 [m]
Height: 24,4 [m]



Albert memorial,
Albert Square, Manchester

2. Conclusion

1) The scaffold meets the checks described in Chapter 7.

check		
Scaffold unity check Steel	1,06 > 1,00	Acceptable*
Coupler unity check	1,00 ≤ 1,00	Check!

**Based on research report OR64 [H03], an unity check overload in Scia of up to 108% (steel check is max. 1.08) is permissible for elements with a round cross section of 48.3x3.2mm, provided that the normal force in the relevant bar is very small (3% of the allowable capacity).*

1) The scaffold design can be erected in a safe way.

2) Maximum vertical standard load at ultimate limit state: $F_{E,d,standard}$ = 45.8 [kN]

3) 34 x 1000kg kentledge; concrete blocks 0.75x0.75x0.75m. Total counterweight = 34 000kg.

4) Total Self Weight scaffold: Factored (Ultimate limit state) = 86 000kg. Unfactored (Serviceability limit state) = 64 000kg.

Note:

Lendlease **is responsible for checking all adjacent structures that loads from the scaffold will be transferred into. This is to be completed in a timely manner.**

The check must be done based at the provided loads. If more information is needed please contact the BrandSafway (Brand Energy & Infrastructure Services, SGB, Lyndon SGB, Hünnebeck and Aluma Systems, hereafter referred to as Brand), Scaffold Design Engineer.

Decimal separators comment: Comma is used to decimal.

3. Basics for the static calculation

[N01] Dutch directive: Richtlijn Steigers; www.richtlijnsteigers.nl
[N02] EN 74-1: Couplers, spigot pins and baseplates for use in falsework and scaffolds
[N03] EN 39: Loose steel tubes for tube and coupler scaffolds – Technical delivery conditions
[N04] EN 12810-1: Façade scaffolds made of prefabricated components – Part 1: product specifications
[N05] EN 12810-2: Façade scaffolds made of prefabricated components – Part 2: Particular methods of structural design
[N06] EN 12811-1: Temporary works equipment – Scaffolds – Performance requirements and general design
[N07] EN 12811-2: Temporary works equipment – Part 2: Information on materials
[N08] EN 12811-3: Temporary works equipment – Part 3: Load testing
[N09] EN 12812: Falsework – Performance requirements and general design
[N10] EN 1990: Eurocode 0: Basis of structural design + NA
[N11] EN 1991-1-3: Eurocode 1: Actions on structures – Part 1-3: General actions – snow loads + NA
[N12] EN 1991-1-4: Eurocode 1: Actions on structures – Part 1-4: General actions – wind actions + NA
[N13] EN 1991-1-6: Eurocode 1: Actions on structures – Part 1-6: General actions – Actions during execution + NA
[N14] EN 1993-1-1: Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings + NA
[N15] EN 1999-1-1: Eurocode 9: Design of aluminium structures – Part 1-1: General structural rules.+ NA
[N16] TG20 Design guide: Technical guidance on the use of BS EN 12811-1
[N17] TG20 Operational guide: A comprehensive guide to good practice for tube and fitting scaffolding.
[N18] BS 2482 – specifications for timber scaffold boards

In addition to the documents above, Brand's own standards regarding scaffold approvals and testing are used:

[H01] CUPLOK Zulassung Z-8.22-208; CUPLOK Node
[H02] Dutch research report OR64; Cuplok schakel Mplastisch, d.d. 4-3-2014
[H03] Dutch research report OR66; Gebruikslasten volgens Eurocode en Normen, d.d. 21-11-2013
[H04] Dutch research report OR85; Veerstijfheid Ux koppelingen
[H05] Dutch research report OR92; Wind reductiefacor PsiW, d.d. 19-12-2014
[H06] Test report P808; Resultaten wrijvingstesten NR-SBR
[[H07] SSM handbook: Offshore Interface Procedure
[H08] Layher AllroundGerüst Modulsystem Zulassung Z-8.22-64; Allgemeine bauaufsichtliche Zulassung
[H09] Layher AllroundGerüst LW Modulsystem Stahl Zulassung Z-8.22-939; Allgemeine bauaufsichtliche Zulassung
[H10] Layher allround technical brochure; Ultimate capacities, approved load bearings and standard configurations
[H11] TNO-rapport; TNO-060-DTM-2011-03086; Veiligheidsbeoordeling bestaande bouw. Achtergrondrapport bij NEN 8700
[H12] VSB.01.A.2020 Annex Windbelasting. Nederlandse ANNEX voor windbelasting op steigers; aanvulling op NEN-EN 1991-1-4

Unless noted otherwise the documents are assumed to be the latest revisions.

4. Modelling

4.1. Calculation model

For analysis of the static calculations, Brand uses the program “NEMETSCHEK Scia Engineer”.
This is a program to model 3D designs and calculate them using 2nd order, geometric non-linear methods.

4.2. Section and material properties

4.2.1. Materials Tube-Lock / tube and fitting

The applied materials and their properties are described in the Scia Engineer calculation report. Additionally the following parts are used in combination with Tube-Lock / tube and fitting:

- Decking: - Timber decking [N18] suitable for all load classes with intermediate supports.
- Class B right angular couplers and class A swivel couplers [N02].

4.2.2. Connection springs

The stiffness values and capacities of the system nodes and loose couplers are applied in the calculation models.

The following properties are used:

Table 1: Connection springs loose couplers

Connections loose couplers	**Stiffness**		**$M_{R,k}$; F_k**		γ_M	**$M_{R,d}$; F_d**	
Right Angular coupler (cruciform stiffness)*	15,0	[kNm/rad]	0,80	[kNm]	1,1	0,73	[kNm]
Right Angular coupler (rotation stiffness)*	7,5	[kNm/rad]	0,13	[kNm]	1,1	0,12	[kNm]
Right Angular coupler (pull/push)*	4400 (min.2000 – max.10000)	[kN/m]	15,0	[kN]	1,1	13,6	[kN]
Swivel coupler (pull/push)*	1500 (min.1000 – max.5000)	[kN/m]	10,0	[kN]	1,1	9,09	[kN]

* acc. to [N07/H04]

4.2.3. Support points

Contact points of the scaffold with the ground and adjacent structures (= contact with the ground and adjacent structures, both vertically and horizontally, on which the scaffold is footed, is suspended from and/or is anchored to/propped against) are applied as support points in the calculation model.

The support points which are applied are checked with the following capacities:

Table 2: Support points capacities

Support point	Capacity F_d	
Cuplok base jack* (pressure)	49,5 – 105	[kN]
Cuplok beam hanger (tension force)	22,5	[kN]
Layher base jack* (pressure)	29,7 – 93,3	[kN]
Tube-Lock connection (tension force)	66,0	[kN]
Beam clamp with safety bolt (tension force)	22,5	[kN]
Beam clamp with safety bolt (slipping force)	4,5	[kN]
Beam clamp (without safety bolt) (tension force)	13,5	[kN]
Anchor eye bolt in brickwork/masonry (tension force)	4,65	[kN]
Anchor eye bolt in brickwork/masonry (pressure)	13,65	[kN]
Anchor eye bolt in concrete (tension force)	12,45	[kN]
Anchor eye bolt in concrete (pressure)	13,65	[kN]
Anchor angled profile in concrete (tension force)**	7,5 - 9,0	[kN]
Anchor angled profile in concrete (pressure)**	7,5 - 13,65	[kN]

* Capacity depends on jack height.
** Capacity depends on the direction in which the anchor tube is mounted.

These capacities are default values. In the case of deviating support points, these must be checked against the actual bearing capacity given by supplier or field tests.

The scaffold design is checked for overturning, sliding and uplift.

For this the following static friction coefficients will be used, according to [N09], annex A

Table 3: Support point friction coefficients

Friction support point	Friction coefficient μ
Steel – Timber	0,5
Timber – Concrete	0,6
Steel – Concrete	0,3
Steel – Steel	0,2

With use of the Cuplok jack sleeve, the following friction coefficients will be used, according to [H06]

Table 4: Support point friction coefficients Cuplok jack sleeve

Friction support point	Friction coefficient μ
Jack sleeve – Timber	0,7
Jack sleeve – Concrete	0,7
Jack sleeve – Steel	0,6

4.2.4. Partial safety factor for resistances γ_M

The characteristic capacities of all components and connections are divided by the partial safety factor, γ_M = 1,1 [N06]. γ_M calculates for imperfections in the structure and compositions of components.

4.3. Geometric imperfections

According to EN 12811-1 (§10.2.2) [N06] and EN 1993-1-1 (§5.3.2) [N13] the geometric imperfections to be considered are inclination and bow imperfections.

The following imperfections are used:

4.3.1. Initial global inclination

Global inclination tan(φ) = 1/200

4.3.2. Initial local bow imperfection

For all scaffold components, buckling curve c is applicable.

$$\frac{e_0}{L} = \frac{1}{200}$$

L = member system length.
In the calculations the bow imperfections are automatically directed to the most unfavourable direction.

5. Loads

5.1. Load cases

In the static calculations the following load cases must be considered:

- Self-weight of the designed structure;
- Safe use load;
- Wind load;
- Snow load;
- Special loads.

5.2. Self-Weight

The weight of the components in the designed structure are calculated by the software. To account for the extra weight of the cups, blades and couplers, the density of the standards, transoms and decking is adjusted in accordance with technical background report: [H04]. Self-weight of decking and toe boards are entered as plane-, line- or point loads.

When counterweight / kentledge is used, it is part of the self-weight load case.
In this project 1000kg concrete blocks are used as counterweight / kentledge.

5.3. Safe use load

Scaffolds can be used for different purposes. Depending on the purpose, the safe use load will be determined. These are distinguishable as live load, assembly load and access route load.

5.3.1. Live load

The live load on a scaffold depends on the selected load class.
According to EN 12811-1 [N06] there are 6 different load classes, see below table.
In special cases other working loads may be applied, depending on the type of work.

Table 5: Load classes

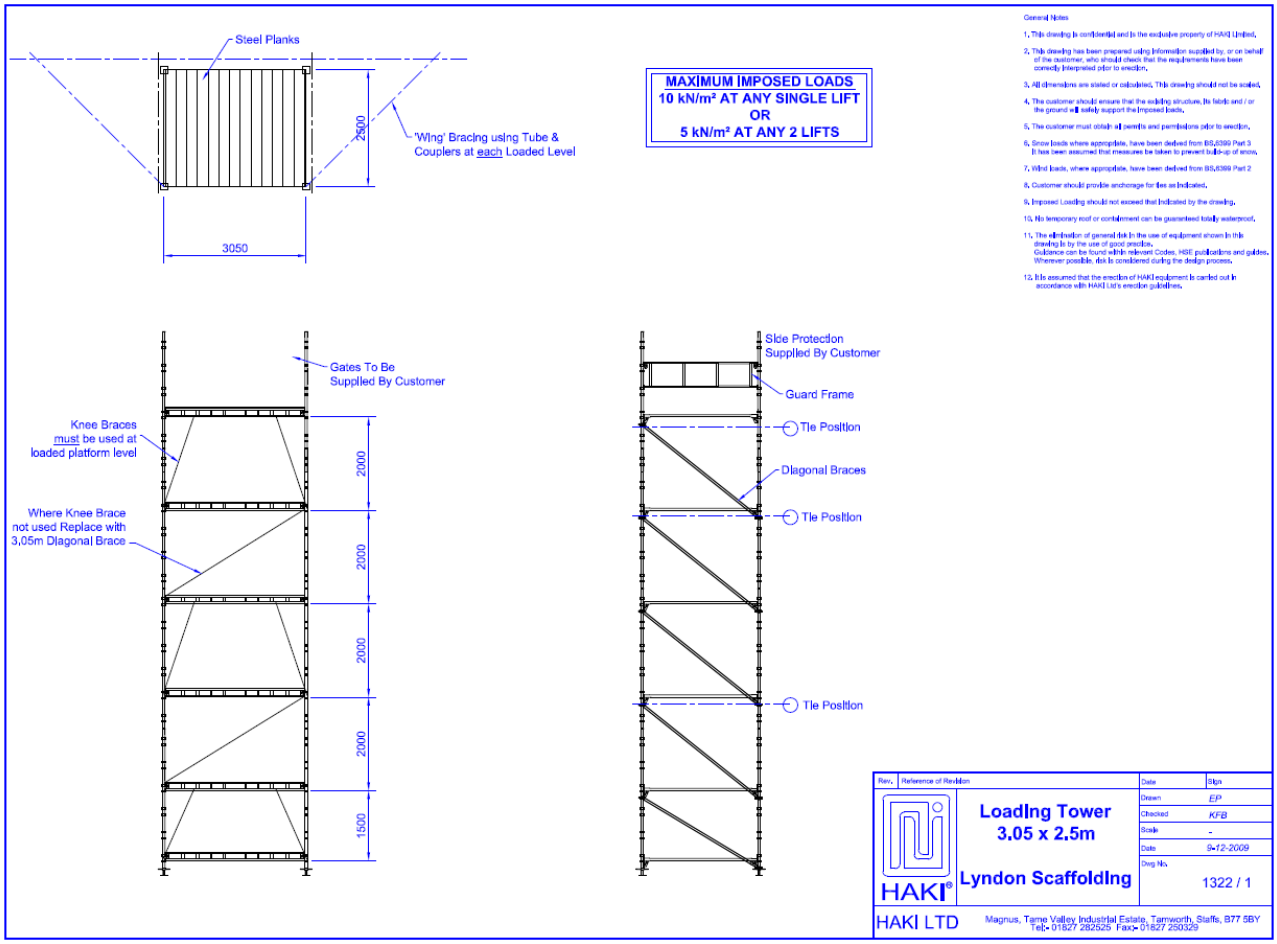
Load class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
uniformly distributed load	0,75 kN/m²	1,50 kN/m²	2,00 kN/m²	3,00 kN/m²	4,50 kN/m²	6,00 kN/m²
partial plane load	-	-	-	5,0 kN/m²	7,5 kN/m²	10,0 kN/m²
factor partial plane	-	-	-	0,4	0,4	0,5

For this project Class 4 is chosen.

5.3.1. Loading deck

Several 500kg/m² loading decks are present in the design. These loading decks may not be loaded simultaneously.

There is also a HAKI standard loading tower 3.05m x 2.5m on the side of the design, according to drawing number: 1322 / 1 date 09-12-2009. It is tied to the scaffolding structure at the height of each level.



5.3.2. Assembly load

When scaffold decking (incl. scaffold roofs) will just be loaded during assembly or when the required allowable working load is < 1,0 kN/m², the assembly load must be taken into account.
In this case a uniformly distributed load of 1,0 kN/m² will be applied to the most unfavourable assembly location with an area of 6 m². [H03].

5.3.3. Walk load

When the scaffold (fully or partially) is used as passenger transport, such as a bridge or a stairway, then an access route load of 1,0 kN/m² on all stair parts and decks of the walkway/landing, in the most unfavorable height of 10 meters, must be applied [H03].

5.4. Wind load United Kingdom

For the purpose of the calculation, two wind loads are taken into account.

- Full wind. This is the possible extreme wind load that occurs in the Netherlands, depending on location, environment, height and period.
- Working wind. The wind load on the scaffold in the working situation, depending on height and period [N06]. This work wind corresponds to a wind speed of 13,8m/s or a working velocity pressure of 200N/mm². Working wind is determined by multiplying the maximum wind with factor ψ_w. [H05]

Wind loads shall be calculated by assuming that there is a velocity pressure on a reference area of the scaffold, which is in general the projected area in the wind direction. The wind force, Fw, in kN/m², is obtained from equation:

$$F_w = C_s C_d \times C_f \times q_p(Z_e) \times A_{ref} \times C_s$$

where:

C_sC_d	=	Structural factor. The product of a size factor C_s, and dynamic factor C_d [N12]
C_f	=	Aerodynamic force / pressure coefficient scaffold. [N06 and N12].
$q_p(z_e)$	=	Velocity pressure acting on the scaffold [kN/m²]. [N12]
A_{ref}	=	Reference area of the scaffold on which the wind acts. [N12]
C_s	=	Site coefficient. [N06]

5.4.1. Wind regions of United Kingdom

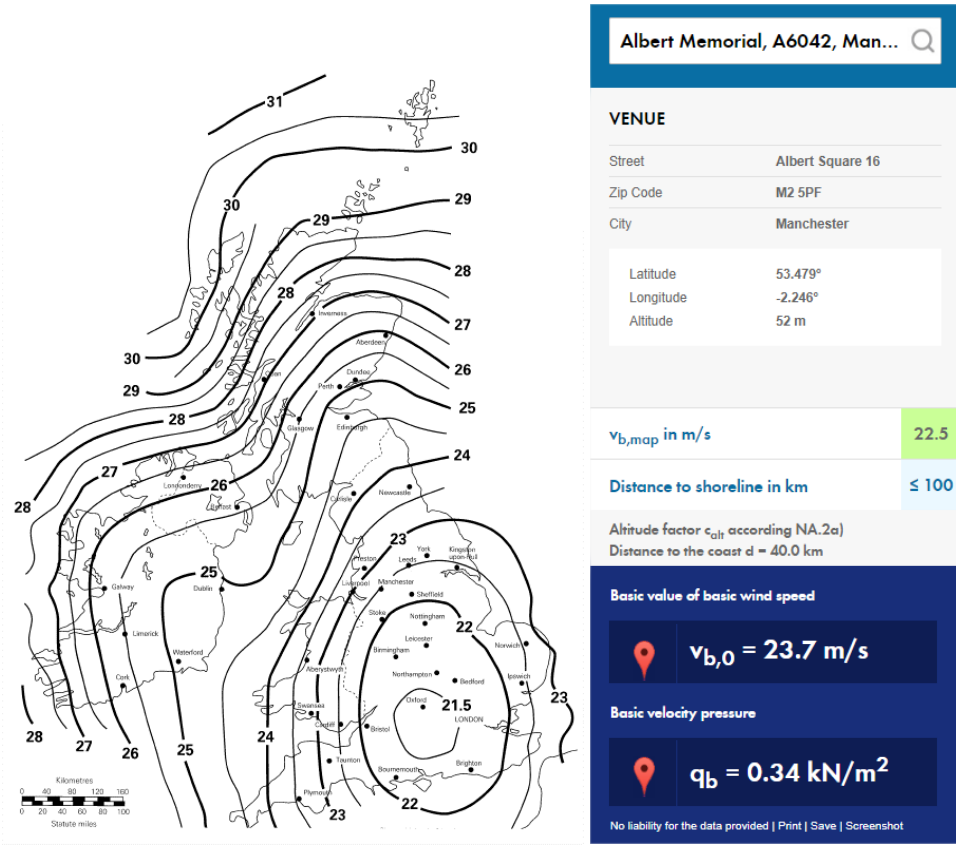


Figure 1: Wind regions of United Kingdom.

Applied wind region, relevant coefficients, wind pressure values, and calculated wind loads are described in Annex 1, wind load and based on simple method according to TG20 13 [N16 and N17].

The location of this project is OTH, Manchester Town Hall.
The calculated Vb,map is 22,5, Altitude A = 52, Twind = 1,00 and distance to sea = 10km.
Terrain category: Town.

5.4.2. Reference period scaffold

Independent of the actual service life (period of assembly up to and including disassembly) and design period, a minimum reference period of 2 years for the wind load should be used when the scaffold falls into consequence class CC1b through to CC3. For consequence class CC1a a minimum reference period of 1 year is allowed for the wind load.

➔ **The client demanded that a 50 years period be maintained for the reference period.**

5.4.3. Statistical reduction factors wind velocity pressure

The full wind velocity pressure may be reduced based on 3 different factors. Namely the wind direction factor C_{dir}, season factor C_{season} and the probability factor C_{prob}. However, the resulting factor **may not be less than 0.84** (based on the minimum factor of 0,7 on the wind velocity pressure, described in chapter 6.2.7.4.1 according to EN 12811-1 [N06] and TG 20 [N16]). This ensures that the safety level indicated in Eurocode is guaranteed. [N10], [H11].

It was agreed with the customer that for this project the wind direction factor C_{dir} may be applied based on table NA.1 from BS EN 1991-1-:2005, NA.2.6

NA.2.6 Directional factor, c_{dir}
[BS EN 1991-1-4:2005, 4.2 (2)P Note 2]

The directional factor c_{dir} is given in Table NA.1.

Table NA.1 **Directional factor c_{dir}**

Direction	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
c_{dir}	0,78	0,73	0,73	0,74	0,73	0,80	0,85	0,93	1,00	0,99	0,91	0,82

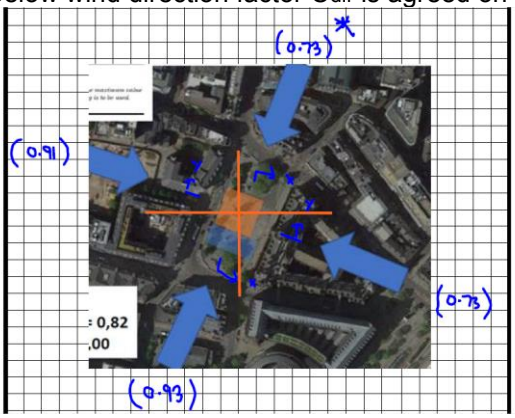
NOTE 1 Interpolation may be used within Table NA.1.

NOTE 2 The directions are defined by angles from due North in a clockwise direction.

NOTE 3 Where the wind loading on a building is assessed only for orthogonal load cases, the maximum value of the factor for the directions that lie ± 45° either side of the normal to the face of the building is to be used.

NOTE 4 Conservatively, c_{dir} may be taken as 1,0 for all directions.

Below wind direction factor C_{dir} is agreed on with customer.



Season factor C_{season} and the probability factor C_{prob} are 1,00 for this project.

Only 2 normative directions are taken into account, due to symmetry and influence cabins.

1) North to South direction; C_{dir} = 0,73
2) West to East direction; C_{dir} = 0,93

See Annex 1 for more detailed information

5.5. Snow load

When the scaffold is used in winter, it is possible that it can be covered in snow.
For this project, due to period and overall shape, snow loads has not been taken into account.

5.6. Special loads

5.6.1. Lifting frame in a scaffold

As a lifting device the NIKO scaffolding Runway system is used, Niko profile 26.000; SWL = 500kg. Exact location to be determined in the field. Fixation and usage according to manufacturer's manual. Only one runway may be used at once.

To allow for dynamic forces introduced by the vertical movement while lifting and practical inaccuracies, the static weight of the lifted load, including lifting equipment, is increased by 20%.

This means the load factor (independent of the consequence class) for the lifted load has to be increased so a resulting (minimum) 120% of the characteristic lifted load is calculated.

5.6.1.1. **Vertical load**

For vertical loads a dynamic factor if 20% is applied to the lifted load.

Example load factor for the calculation of the vertical lift load in CC2:

- Vertical component **(100%)**: 1,5 **x 1,2** = 1,8.
    - This results in 120% of the characteristic hoist load.

5.6.1.2. **Horizontal load**

When the load is lifted and a small horizontal load or movement is expected, 10% (or a value given by the customer) of the characteristic hoist load must be added as a horizontal component.

5.6.2. Horizontal dynamic loading

The dynamic effects of horizontal moving loads are represented by an equivalent static force of 10% of the weight of the item.

5.6.3. Hoist connected to a scaffold

When a hoist is directly connected to the scaffold, the hoist loads have to be considered. Hoist loads depend on the type of hoist that is being used. They are derived from the technical documentation from the hoist supplier.

For this project. The 500kg hoist is tied to the cabins and NOT to the scaffold.

6. Load combinations

For a construction, the load factors are determined by consequence classes. The consequence class is based on the consequences of the loss of life and / or economic or social consequences [N10]. Every situation (= load combination) can be viewed separately.

For this project the following load combination table is used.

Table 6: Load combinations

Consequence class CC1/CC2		Load case				
	Load combination	**Self Weight**	**Safe use load**	**Lift load (vert.)**	**Lift load (hor.) (10%)**	
CC2	Self weight	1,35	0	0	0	
CC2	In service	1,35	1,5	1,2[5)] x 1,5	1,1[5)] x 1,5	
CC1	Full wind	1,22	ψ_p [2)] x 1,35	0 / 1,35 [4)]	0 / 1,35 [4)]	
CC1	overturning [3)]	0,9 / 1,22	0 / ψ_p [2)] x 1,35	0 / 1,35	0 / 1,35	

1) Reduced wind load ψ_w according to [H05], see table in annex 1.

2) Reduced safe use load depending on load class.
Load class 1 → $\psi_p = 0$; Load class 2 and 3 → $\psi_p = 0{,}25$; Load class 4, 5, and 6 → $\psi_p = 0{,}50$

3) When the load case increases the overturning effect, then the highest load factor must be applied. If the overturning effect is counterweighted by the load case then the lowest load factor is applied.

4) Dependant of the duration of the lift load in the lifting frame.
0 when the complete lifted action, including removal of the lifted loads will be done during one single shift. (wind loads < 7 Bft).

5) Factor should be 1,2 when the horizontal component < 45% of the vertical component.
Factor also can be calculated between 1,1 and 1,2 where the resulting factor of the vertical and horizontal component increases the characteristic value of the lift load with at least 20%.

7. Unity check

7.1. Scaffold unity check

The unity check of the elements is verified using the following formulas:

7.1.1. Axial force

$$\frac{N_{Ed}}{N_{c,Rd}} \leq 1{,}0$$ According to EN 1993-1-1, §6.2.4 [N14]

7.1.2. Shear force

$$\frac{V_{Ed}}{V_{c,Rd}} \leq 1{,}0$$ According to EN 1993-1-1, §6.2.6 [N14]

7.1.3. Bending moment

$$\frac{M_{Ed}}{M_{c,Rd}} \leq 1{,}0$$ According to EN 1993-1-1, §6.2.5 [N14]

7.1.4. Scaffolding tubular member check

$$\frac{M_{s,d}}{M_{pl,d} \times cos\left(\frac{\pi \times N_{s,d}}{2N_{pl,d}}\right)} \leq 1{,}0$$ According to EN 12811-1, §10.3.3 [N06]

7.2. Coupler unity check

7.2.1. Right angular couplers

The unity check of the coupling depends on the capacities (described in section 3.2.2). In addition, the right-angular couplers are verified by the following interaction formula.

$$\frac{F_{s1}+F_{s2}}{2F_{s,d}} + \frac{F_p}{F_{p,d}} + \frac{M_B}{2{,}4M_{B,d}} \leq 1{,}0$$ According EN 12811-1, §10.3.3 [N06]

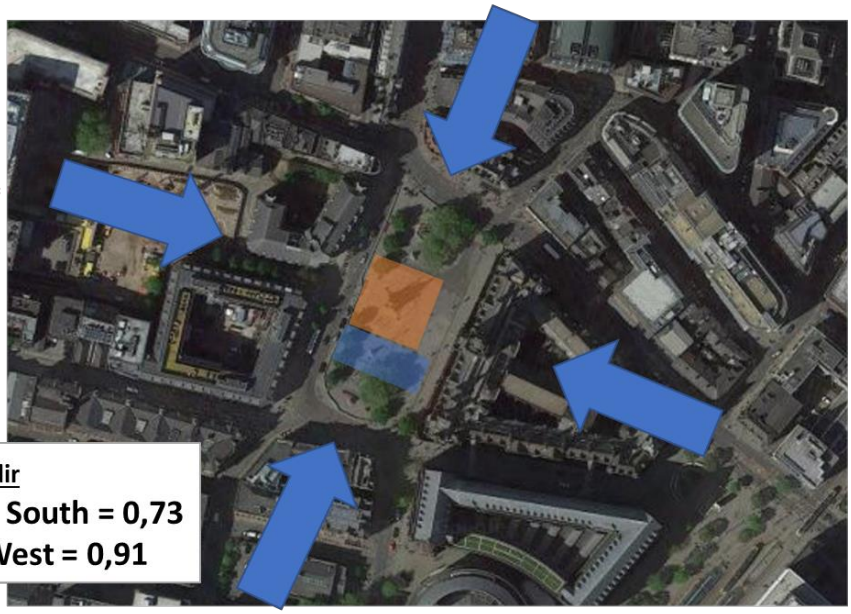
Annex 1: Wind loads

Annex 1A: C_{dir}

North

20°
C_{dir} = 0,73*

290°
C_{dir} = 0,91*



West

East

110°
C_{dir} = 0,73*

Project C_{dir}
North <-> South = 0,73
East <-> West = 0,91

200°
C_{dir} = 0,93*

→ Cabins are shielding scaffold for a big part: global **C_{dir} = 0,73***

South

*Lower C_{dir} accepted, due to C_{prob} =1,00



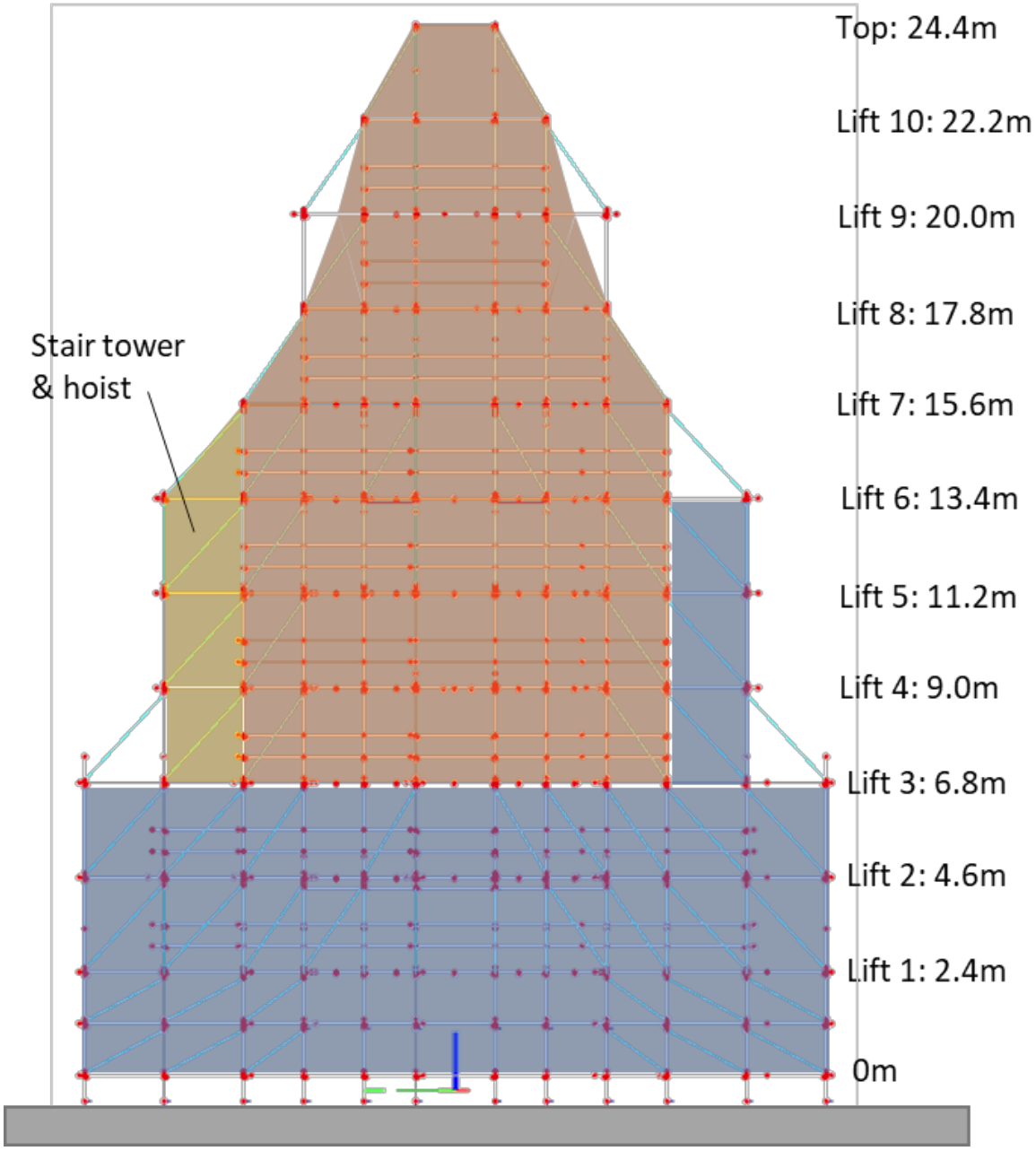
Keep in mind:

- Cdir x Cseason x Cprob ≥ 0,84 (=√(0,7)) = 0,73 x 1 x 1 = 0,73 -> 0,84

Full wind velocity pressure is reduced with a minimum of **0,84** and not with 0,73 related to minimum likelihood for safety of people on or in structures.

Annex 1B: North -> South wind load

Unclad



Wind load:

$F_{w,rep} = 0{,}23 kN/m^2$

Wind load birdcage scaffold

According to EN 1991-1-4 & NA / EN 12811-1 / Richtlijn Steigers / TG20-13 2021V1.00

Scaffolding location data

- Country	=	United Kingdom
- Wind region & terrain	=	Vb,map = 22,5 m/s, Tw =1, Town
- Consequence class	=	CC1b
- Date of erection	=	Not applicable
- Date of dismantling	=	Not applicable
- Cdir x Cseason x Cprob ≥ 0,84 (=√(0,7))	=	0,73 x 1 x 1 = 0,73 -> 0,84
- Start height scaffold	=	0 m
- Maximum scaffolding height	=	6,8 m
- Width (plane perpendicular to wind direction)	=	17,2 m
- Type of scaffolding	=	Access scaffold
- Density of adjacent façade or object	=	Not applicable
- Sheeting scaffolding	=	Unclad
- Type of roof construction	=	No roof
- Wind reduction factor Ψw1: Work wind (up to 7 Bft)	=	0,54
- Wind reduction factor Ψw2: Not applicable		

This reduction factor must be multiplied by the partial load factor.

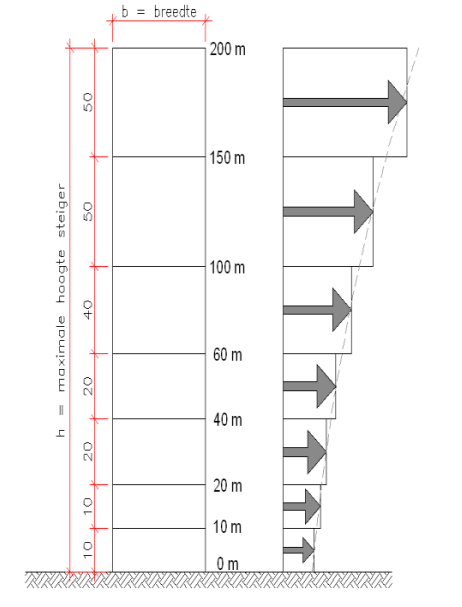
Wind force Fw on the structure is calculated as: $F_w = C_s C_d \times C_f \times q_p(Z_e) \times A_{ref} \times C_s$

- $C_s C_d$	: Structural factor (EN 1991-1-4)	=	0,91	
- C_s	: Site coefficient (EN 12811-1)		1,00	
- A_{ref}	: Total wind-catching area / m²	=	0,51	m²/m²

where: A1= 22 *%, A2 =* 6 *%,*

Number of uprights in a row, n= 10 *legs* $A_{ref} = A_1 + (A_{totaal} - A_1)\left(1 - e^{-0,85(n-1)\times A_2/A_{totaal}}\right)$

- Cf : Force coefficient Cf front:

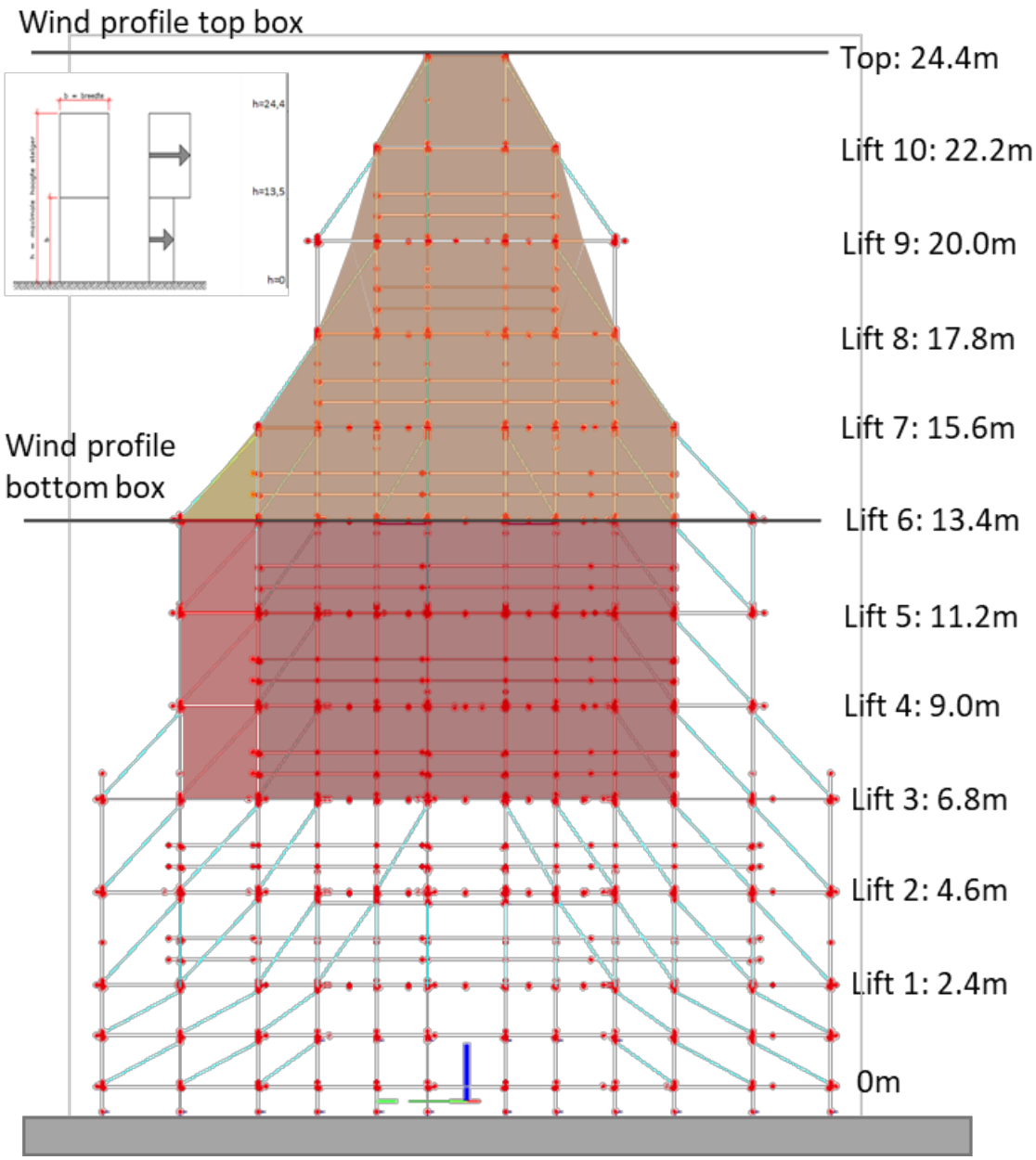


			1,30
	Vel. Pressure		**front**
	Ze [m]	qp(Ze) [kN/m²]	Fw,rep [kN/m²]
h=6,8			
h=0	5	0,39	**0,23**

Altitude above mean sea level =52 m

Closest distance to the sea upwind = 10 km

Lift 3 – 6 Sheeted



Wind load:

$F_{w,rep} = 0{,}61 kN/m^2$

Wind load birdcage scaffold

According to EN 1991-1-4 & NA / EN 12811-1 / Richtlijn Steigers / TG20-13 2021V1.00

Scaffolding location data

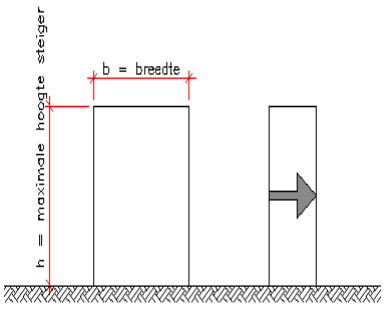
- Country	=	United Kingdom
- Wind region & terrain	=	Vb,map = 22,5 m/s, Tw =1, Town
- Consequence class	=	CC1b
- Date of erection	=	Not applicable
- Date of dismantling	=	Not applicable
- Cdir x Cseason x Cprob ≥ 0,84 (=√(0,7))	=	0,73 x 1 x 1 = 0,73 -> 0,84
- Start height scaffold	=	0 m
- Maximum scaffolding height	=	13,4 m
- Width (plane perpendicular to wind direction)	=	13,5 m
- Type of scaffolding	=	Access scaffold
- Density of adjacent façade or object	=	Not applicable
- Sheeting scaffolding	=	Netting 90% / Sheeting, around
- Type of roof construction	=	No roof
- Wind reduction factor Ψw1: Work wind (up to 7 Bft)	=	0,54
- Wind reduction factor Ψw2: Not applicable		

This reduction factor must be multiplied by the partial load factor.

Wind force Fw on the structure is calculated as: $F_w = C_s C_d \times C_f \times q_p(Z_e) \times A_{ref} \times C_s$

- $C_s C_d$	: Structural factor (EN 1991-1-4)	=	0,92	
- C_s	: Site coefficient (EN 12811-1)		1,00	
- A_{ref}	: Total wind-catching area / m²	=	1,00	m²/m²

- Cf : Force coefficient Cf front:



			1,10		
	Vel. Pressure		**front**		
	Z_e [m]	$q_p(Z_e)$ [kN/m²]	Fw,rep [kN/m²]		
h=13,4					
	13	0,60	**0,61**		
h=0					

Altitude above mean sea level =52 m

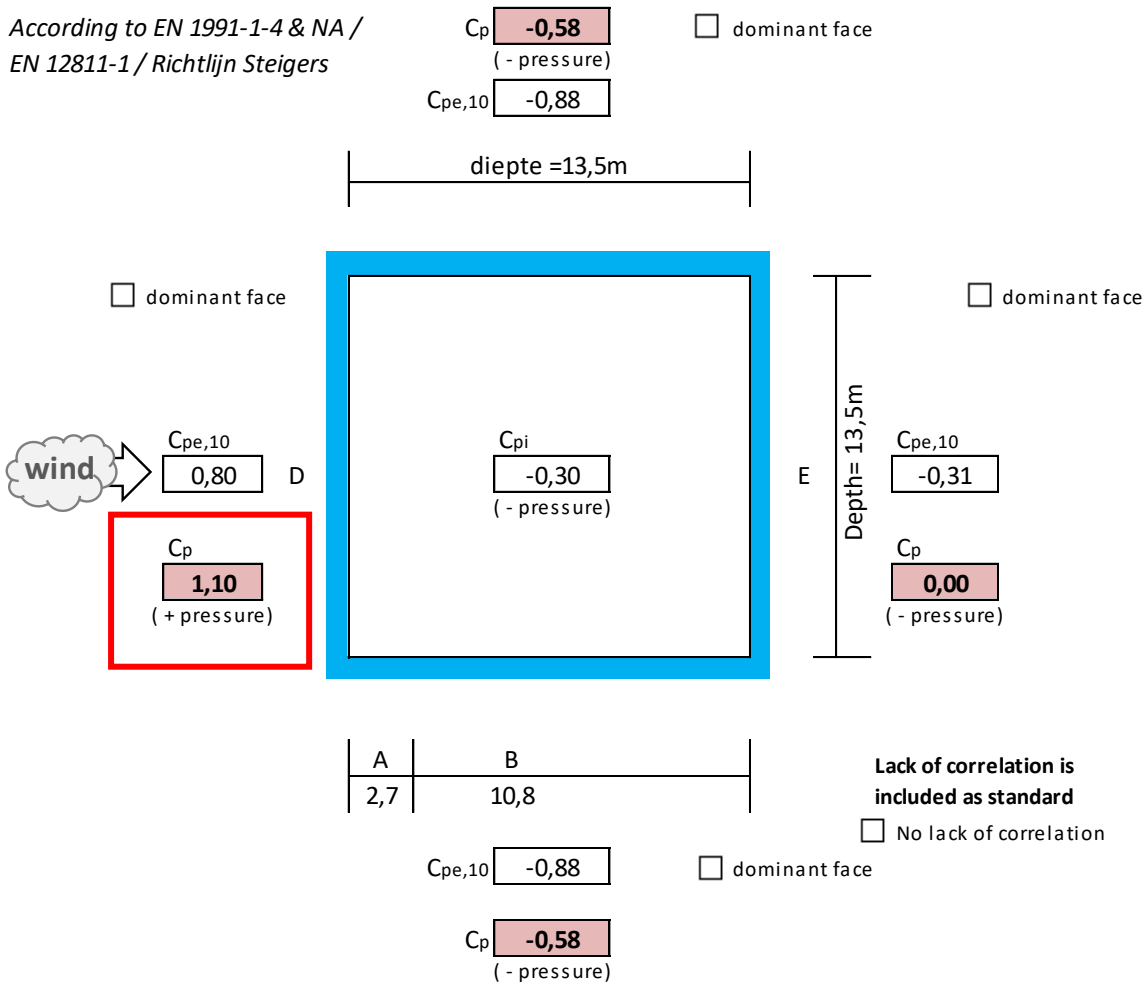
Closest distance to the sea upwind = 10 km

Default pressure coefficient for sheeted walls / roofs (conservative) = Cp = 1,10

Pressure coefficient walls

2021V1.00

According to EN 1991-1-4 & NA / EN 12811-1 / Richtlijn Steigers

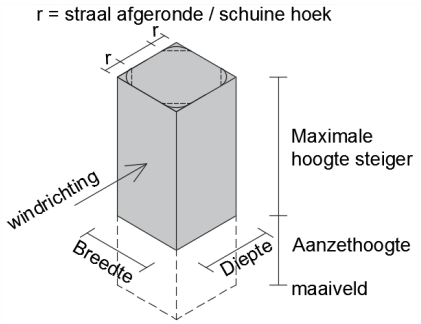


Force coefficient rounded / bevelled corners

According to NEN-EN 1991-1-4 & NA; Hfd 7.6 2021V1.00

General conditions

- b	=	Width	=	13,5	m	m
- d	=	Depth	=	13,5	m	m
- a	=	Start height	=	0	m	m
- h	=	Scaffold height	=	13,4	m	m
- r	=	Radius corner	=	0,8	m	m



$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = The force coefficient of rectangular sections with sharp corners and without free-end flow.
Ψr = The reduction factor for square sections with rounded corners.
Ψλ = The end-effect factor for elements with free-end flow.

Determine force coefficient Cf,0
- Depth / Width; d/b = 1,00
- Force coefficient Cf,0 = **2,10**

Determine reduction factor Ψr
- Radius / Width r/b = 0,06
- Reductution factor Ψr = **0,85**

Determine end-effect factor Ψλ
- Scaffold height = 13,4
- Polygonal section
- Netting 90% / Sheeting, around
- solidity ratio ϕ = 1,0
- slenderness λ = 2,0
- end-effect factor Ψλ = **0,61**

$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = 2,1 x 0,85 x 0,61

Cf rounded	=	**1,10**	***100%***

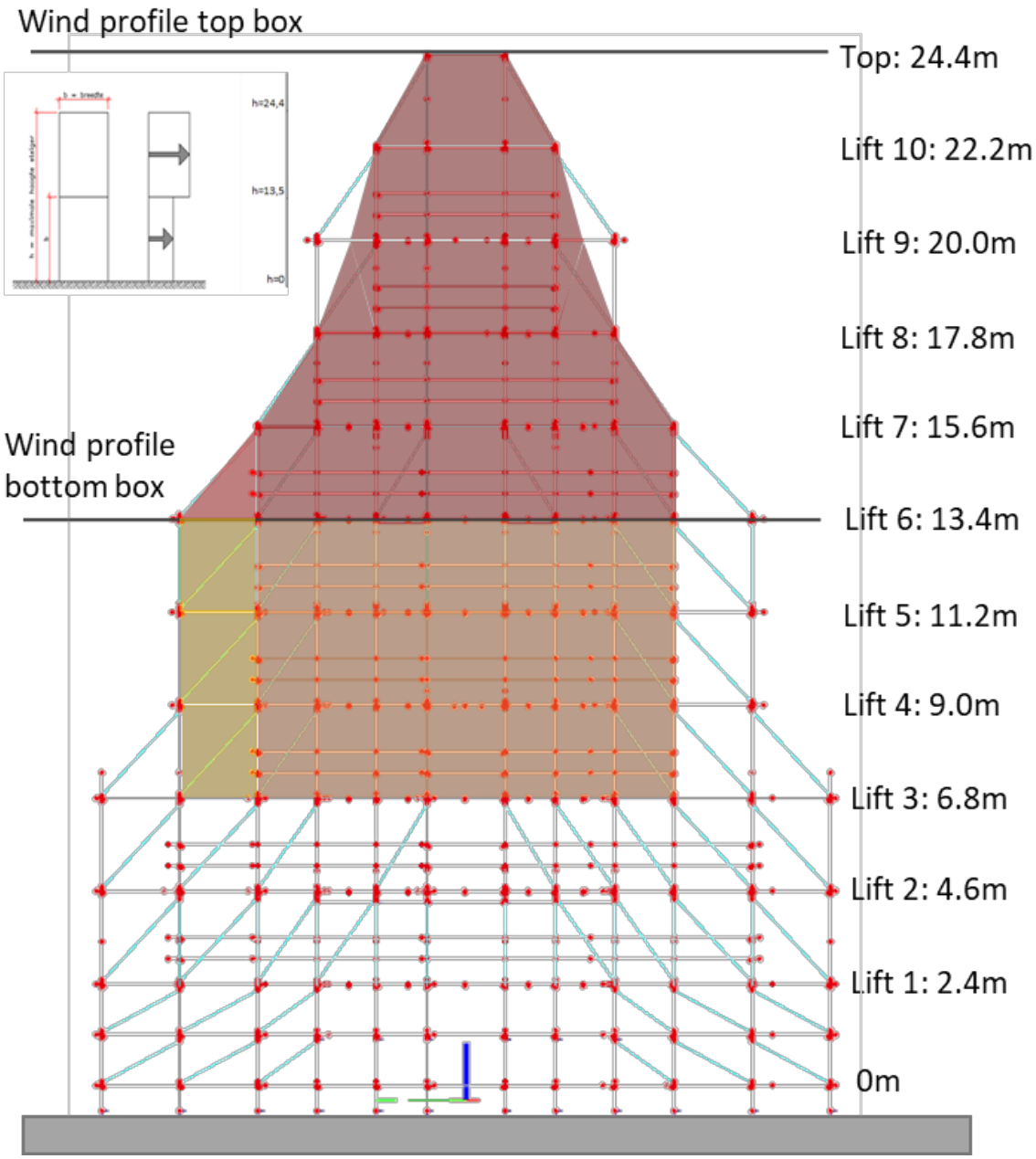
Factor bevelled versus rounded = *1,000*

Cf bevelled	=	**1,10**	***100%***

The '%' is applied in comparison with Cp = 1.10

No overall reduction, due to no influence chamfered corners & roofs!

Lift 6 – Top Sheeted



Wind load:

$F_{w,rep} = 0{,}60 kN/m^2$

Wind load birdcage scaffold

According to EN 1991-1-4 & NA / EN 12811-1 / Richtlijn Steigers / TG20-13 2021V1.00

Scaffolding location data

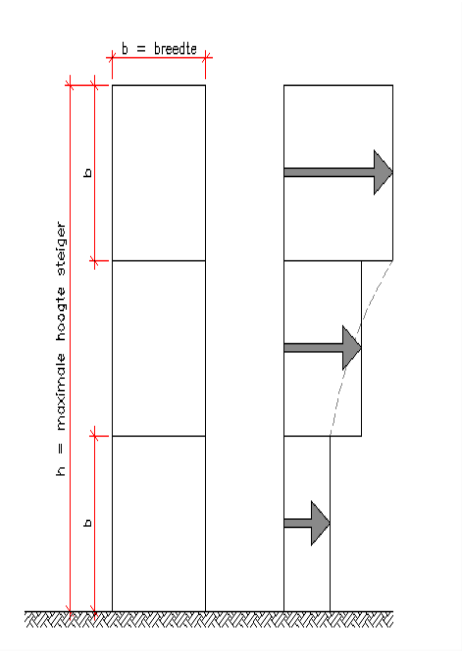
- Country	=	United Kingdom
- Wind region & terrain	=	Vb,map = 22,5 m/s, Tw =1, Town
- Consequence class	=	CC1b
- Date of erection	=	Not applicable
- Date of dismantling	=	Not applicable
- Cdir x Cseason x Cprob ≥ 0,84 (=√(0,7))	=	0,73 x 1 x 1 = 0,73 -> 0,84
- Start height scaffold	=	0 m
- Maximum scaffolding height	=	24,4 m
- Width (plane perpendicular to wind direction)	=	7 m
- Type of scaffolding	=	Access scaffold
- Density of adjacent façade or object	=	Not applicable
- Sheeting scaffolding	=	Netting 90% / Sheeting, around
- Type of roof construction	=	No roof
- Wind reduction factor Ψw1: Work wind (up to 7 Bft)	=	0,54
- Wind reduction factor Ψw2: Not applicable		

This reduction factor must be multiplied by the partial load factor.

Wind force Fw on the structure is calculated as: $F_w = C_s C_d \times C_f \times q_p(Z_e) \times A_{ref} \times C_s$

- $C_s C_d$	: Structural factor (EN 1991-1-4)	=	0,92	
- C_s	: Site coefficient (EN 12811-1)		1,00	
- A_{ref}	: Total wind-catching area / m²	=	1,00	m²/m²

- Cf : Force coefficient Cf front:



			0,89		
	Vel. Pressure		**front**		
	Ze	qp(Ze)	Fw,rep		
h=24,4	[m]	[kN/m²]	[kN/m²]		
	24	0,72	**0,60**		
h=17,4					
	12	0,58	**0,48**		
h=7					
	7	0,45	**0,37**		
h=0					

Altitude above mean sea level =52 m

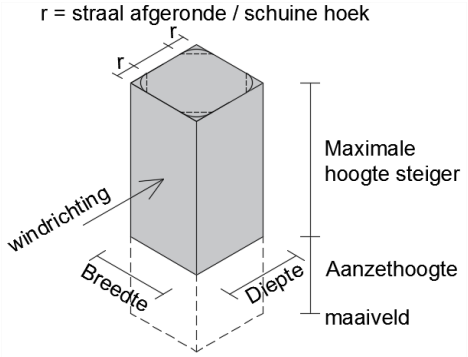
Closest distance to the sea upwind = 10 km

Force coefficient rounded / bevelled corners

According to NEN-EN 1991-1-4 & NA; Hfd 7.6 2021V1.00

General conditions

- b	=	Width	=	7	m	m
- d	=	Depth	=	7	m	m
- a	=	Start height	=	0	m	m
- h	=	Scaffold height	=	24,4	m	m
- r	=	Radius corner	=	1,2	m	m



$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = The force coefficient of rectangular sections with sharp corners and without free-end flow.
Ψr = The reduction factor for square sections with rounded corners.
Ψλ = The end-effect factor for elements with free-end flow.

Determine force coefficient Cf,0

- Depth / Width; d/b = 1,00
- Force coefficient Cf,0 = **2,10**

Determine reduction factor Ψr

- Radius / Width r/b = 0,17
- Reductution factor Ψr = **0,57**

Determine end-effect factor Ψλ

- Scaffold height = 24,4
- Polygonal section
- Netting 90% / Sheeting, around
- solidity ratio ϕ = 1,0
- slenderness λ = 6,4
- end-effect factor Ψλ = **0,66**

$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = 2,1 x 0,57 x 0,66

Cf rounded	=	**0,79**	***72%***

Factor bevelled versus rounded = *1,128*

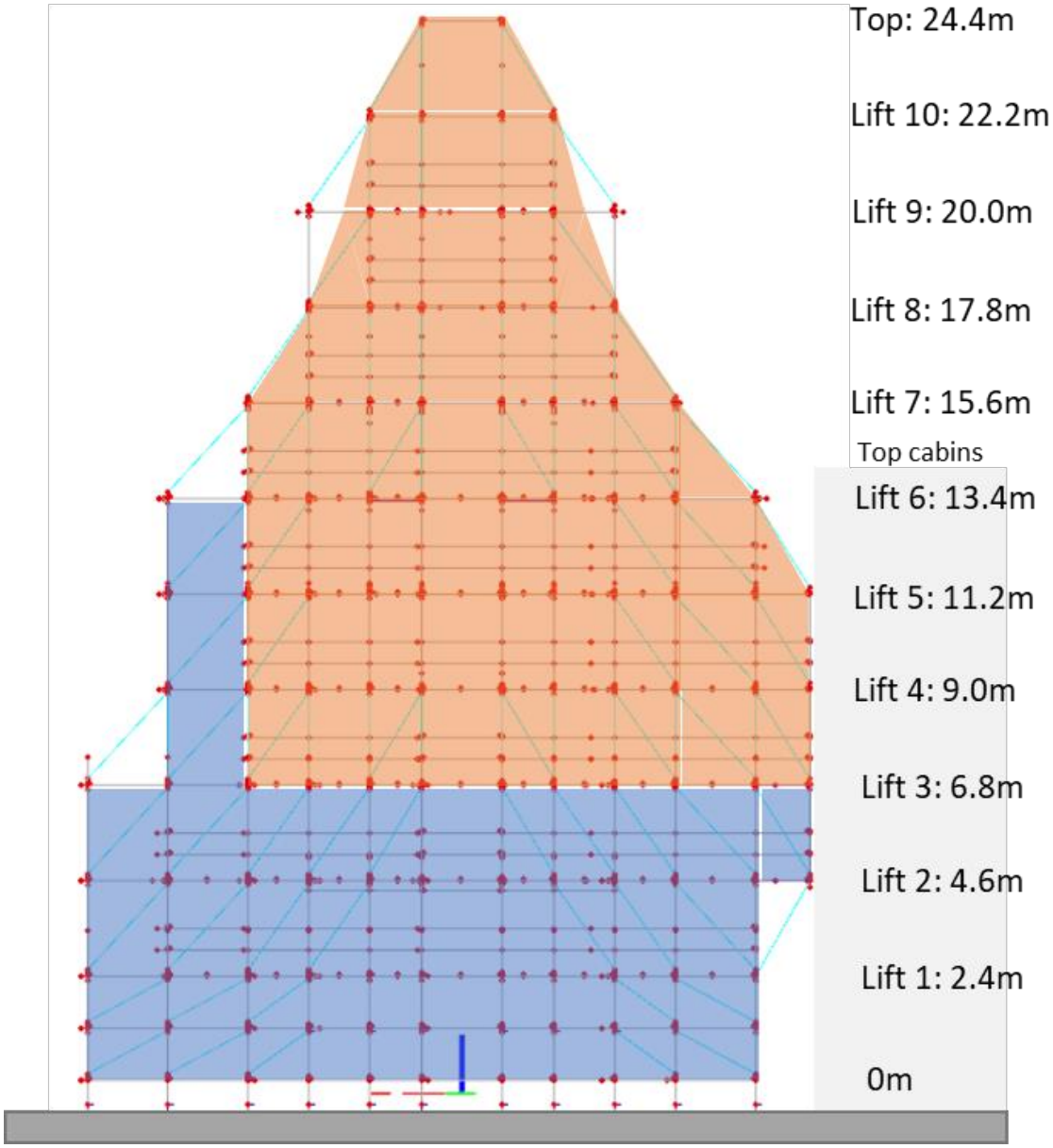
Cf bevelled	=	**0,89**	***81%***

The '%' is applied in comparison with Cp = 1.10

Overall 19% reduction due to influence chamfered corners & roofs!

Annex 1C: West -> East wind load

Unclad



Wind load:

$F_{w,rep} = 0{,}28 kN/m^2$

Wind load birdcage scaffold

According to EN 1991-1-4 & NA / EN 12811-1 / Richtlijn Steigers / TG20-13 2021V1.00

Scaffolding location data

- Country	=		United Kingdom
- Wind region & terrain	=		Vb,map = 22,5 m/s, Tw =1, Town
- Consequence class	=		CC1b
- Date of erection	=		Not applicable
- Date of dismantling	=		Not applicable
- Cdir x Cseason x Cprob ≥ 0,84 (=√(0,7))	=		0,91 x 1 x 1 = 0,91 -> 0,91
- Start height scaffold	=		0 m
- Maximum scaffolding height	=		6,8 m
- Width (plane perpendicular to wind direction)	=		17,2 m
- Type of scaffolding	=		Access scaffold
- Density of adjacent façade or object	=		Not applicable
- Sheeting scaffolding	=		Unclad
- Type of roof construction	=		No roof
- Wind reduction factor Ψw1: Work wind (up to 7 Bft)		=	0,45
- Wind reduction factor Ψw2: Not applicable			

This reduction factor must be multiplied by the partial load factor.

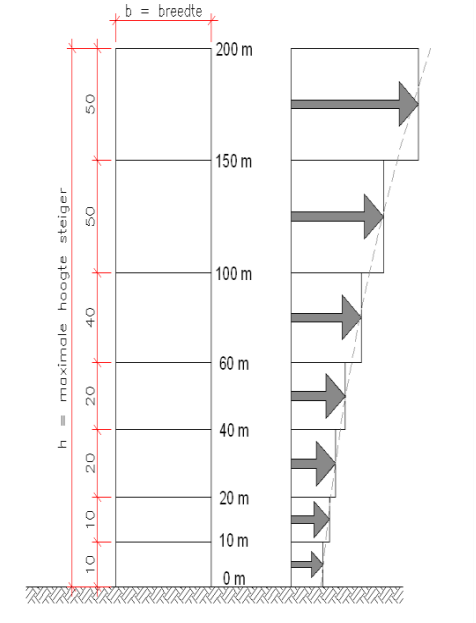
Wind force Fw on the structure is calculated as: $F_w = C_s C_d \times C_f \times q_p(Z_e) \times A_{ref} \times C_s$

- C_sC_d : Structural factor (EN 1991-1-4) = 0,91
- C_s : Site coefficient (EN 12811-1) 1,00
- A_{ref} : Total wind-catching area / m² = 0,51 m²/m²

where: A1= 22 *%, A2 =* 6 *%,*

Number of uprights in a row, n= 10 *legs* $A_{ref} = A_1 + (A_{totaal} - A_1)\left(1 - e^{-0,85(n-1)\times A_2/A_{totaal}}\right)$

- Cf : Force coefficient Cf front:

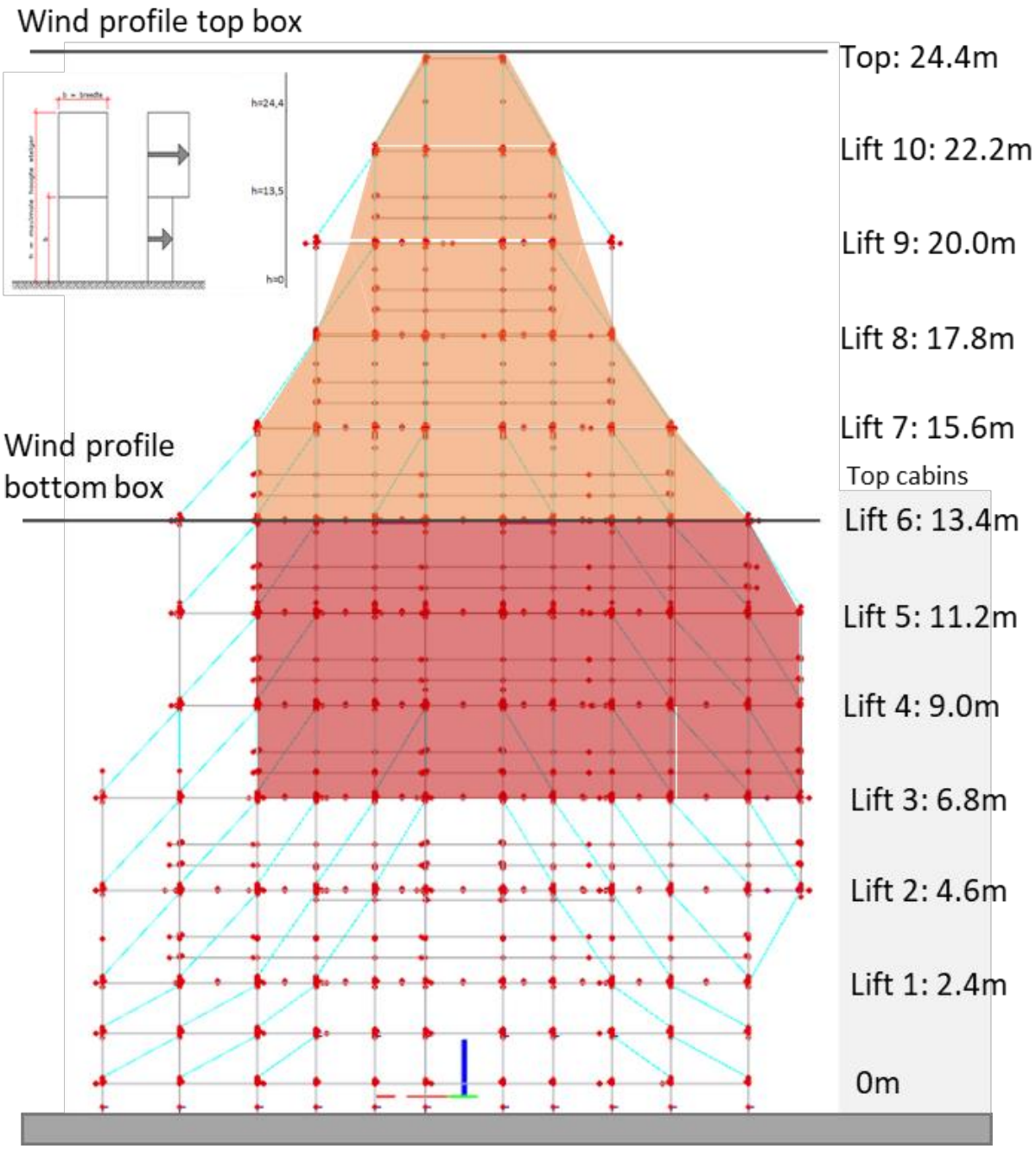


			1,30
	Vel. Pressure		**front**
	Ze [m]	qp(Ze) [kN/m²]	Fw,rep [kN/m²]
h=6,8			
h=0	5	0,46	**0,28**

Altitude above mean sea level =52 m

Closest distance to the sea upwind = 10 km

Lift 3 – 6 Sheeted



Wind load:

$F_{w,rep} = 0{,}72 kN/m^2$

Wind load birdcage scaffold

According to EN 1991-1-4 & NA / EN 12811-1 / Richtlijn Steigers / TG20-13 2021V1.00

Scaffolding location data

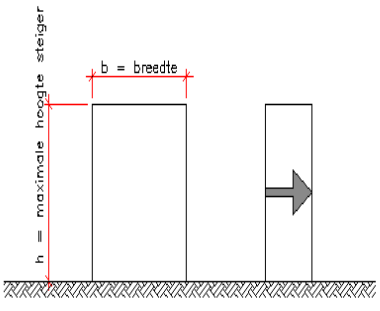
- Country	=	United Kingdom
- Wind region & terrain	=	Vb,map = 22,5 m/s, Tw =1, Town
- Consequence class	=	CC1b
- Date of erection	=	Not applicable
- Date of dismantling	=	Not applicable
- Cdir x Cseason x Cprob ≥ 0,84 (=√(0,7))	=	0,91 x 1 x 1 = 0,91 -> 0,91
- Start height scaffold	=	0 m
- Maximum scaffolding height	=	13,4 m
- Width (plane perpendicular to wind direction)	=	13,5 m
- Type of scaffolding	=	Access scaffold
- Density of adjacent façade or object	=	Not applicable
- Sheeting scaffolding	=	Netting 90% / Sheeting, around
- Type of roof construction	=	No roof
- Wind reduction factor Ψw1: Work wind (up to 7 Bft)	=	0,45
- Wind reduction factor Ψw2: Not applicable		

This reduction factor must be multiplied by the partial load factor.

Wind force Fw on the structure is calculated as: $F_w = C_s C_d \times C_f \times q_p(Z_e) \times A_{ref} \times C_s$

- $C_s C_d$	: Structural factor (EN 1991-1-4)	=	0,92	
- C_s	: Site coefficient (EN 12811-1)		1,00	
- A_{ref}	: Total wind-catching area / m²	=	1,00	m²/m²

- Cf : Force coefficient Cf front:



			1,10		
	Vel. Pressure		**front**		
	Ze [m]	qp(Ze) [kN/m²]	Fw,rep [kN/m²]		
h=13,4					
	13	0,71	**0,72**		
h=0					

Altitude above mean sea level =52 m

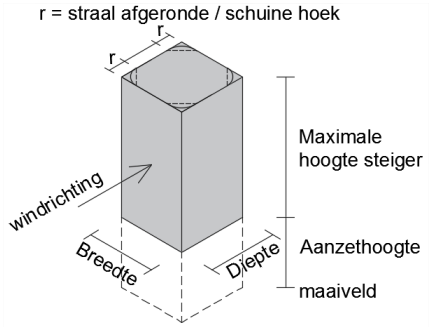
Closest distance to the sea upwind = 10 km

Force coefficient rounded / bevelled corners

According to NEN-EN 1991-1-4 & NA; Hfd 7.6 2021V1.00

General conditions

- b	=	Width	=	13,5	m	m
- d	=	Depth	=	13,5	m	m
- a	=	Start height	=	0	m	m
- h	=	Scaffold height	=	13,4	m	m
- r	=	Radius corner	=	0,8	m	m



$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = The force coefficient of rectangular sections with sharp corners and without free-end flow.
Ψr = The reduction factor for square sections with rounded corners.
Ψλ = The end-effect factor for elements with free-end flow.

Determine force coefficient Cf,0

- Depth / Width; d/b = 1,00
- Force coefficient Cf,0 = **2,10**

Determine reduction factor Ψr

- Radius / Width r/b = 0,06
- Reductution factor Ψr = **0,85**

Determine end-effect factor Ψλ

- Scaffold height = 13,4
- Polygonal section
- Netting 90% / Sheeting, around
- solidity ratio ϕ = 1,0
- slenderness λ = 2,0
- end-effect factor Ψλ = **0,61**

$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = 2,1 x 0,85 x 0,61

Cf rounded	=	**1,10**	***100%***

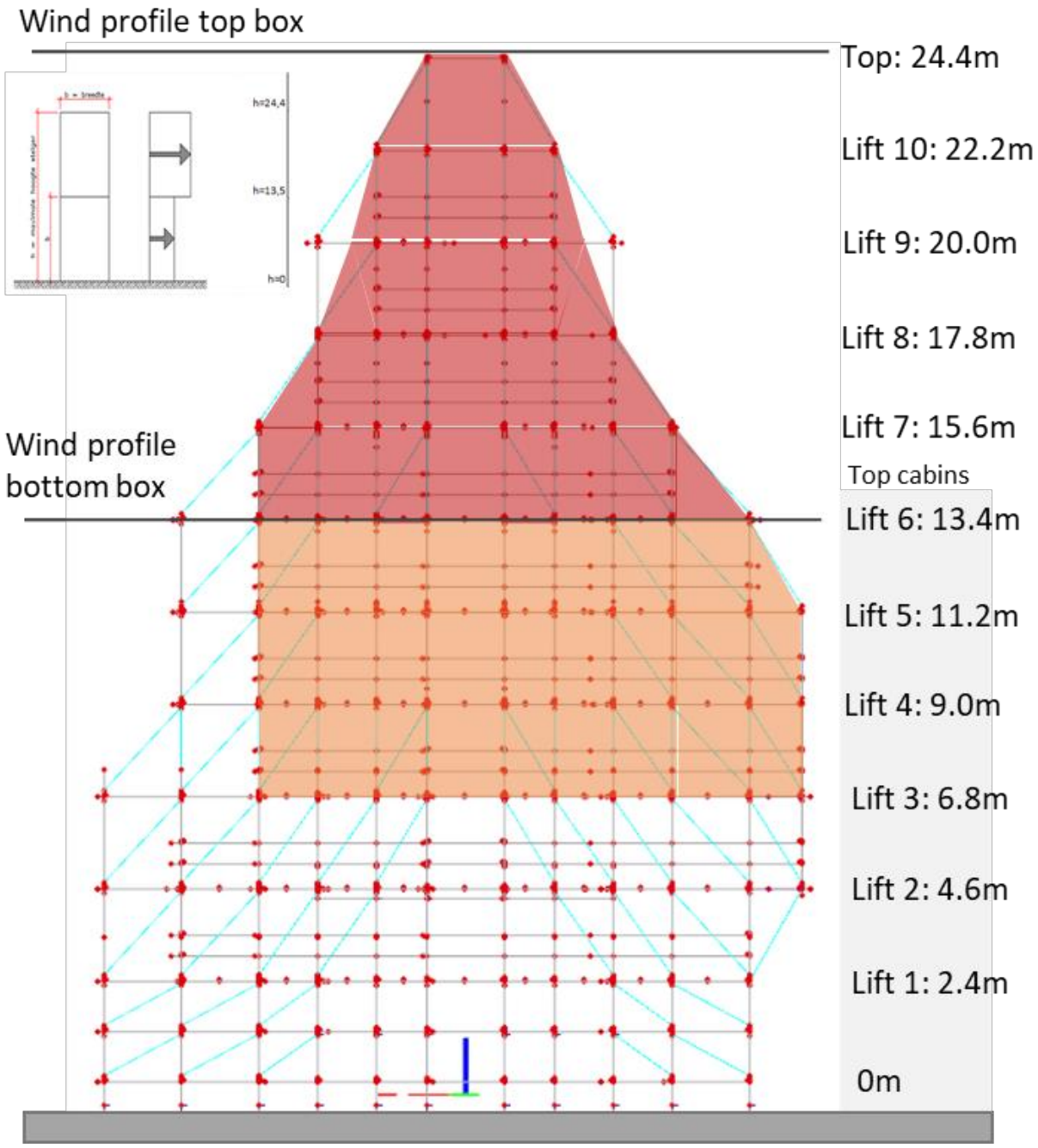
Factor bevelled versus rounded = *1,000*

Cf bevelled	=	**1,10**	***100%***

The '%' is applied in comparison with Cp = 1.10

No overall reduction, due to no influence chamfered corners & roofs!!

Lift 6 – Top Sheeted



Wind load:

$F_{w,rep} = 0{,}71 kN/m^2$

Wind load birdcage scaffold

According to EN 1991-1-4 & NA / EN 12811-1 / Richtlijn Steigers / TG20-13 2021V1.00

Scaffolding location data

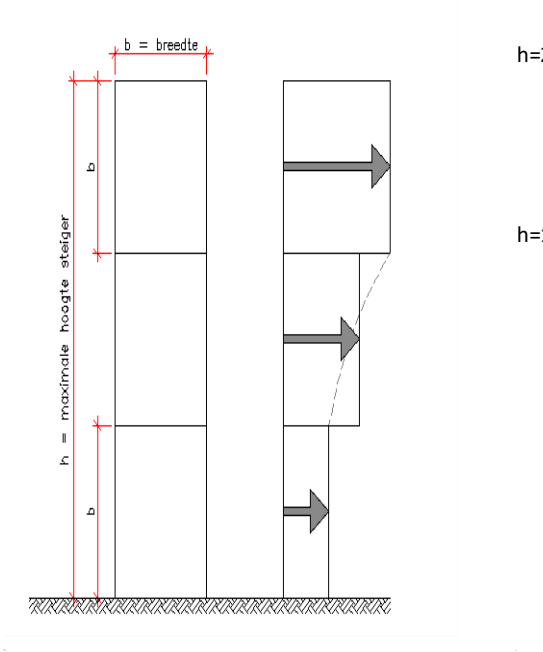
- Country	=	United Kingdom
- Wind region & terrain	=	Vb,map = 22,5 m/s, Tw =1, Town
- Consequence class	=	CC1b
- Date of erection	=	Not applicable
- Date of dismantling	=	Not applicable
- Cdir x Cseason x Cprob ≥ 0,84 (=√(0,7))	=	0,91 x 1 x 1 = 0,91 -> 0,91
- Start height scaffold	=	0 m
- Maximum scaffolding height	=	24,4 m
- Width (plane perpendicular to wind direction)	=	7 m
- Type of scaffolding	=	Access scaffold
- Density of adjacent façade or object	=	Not applicable
- Sheeting scaffolding	=	Netting 90% / Sheeting, around
- Type of roof construction	=	No roof
- Wind reduction factor Ψw1: Work wind (up to 7 Bft)	=	0,45
- Wind reduction factor Ψw2: Not applicable		

This reduction factor must be multiplied by the partial load factor.

Wind force Fw on the structure is calculated as: $F_w = C_s C_d \times C_f \times q_p(Z_e) \times A_{ref} \times C_s$

- $C_s C_d$	: Structural factor (EN 1991-1-4)	=	0,92	
- C_s	: Site coefficient (EN 12811-1)		1,00	
- A_{ref}	: Total wind-catching area / m²	=	1,00	m²/m²

- Cf : Force coefficient Cf front:



			0,89		
	Vel. Pressure		**front**		
	Ze	qp(Ze)	Fw,rep		
h=24,4	[m]	[kN/m²]	[kN/m²]		
	24	0,86	**0,71**		
h=17,4					
	12	0,68	**0,56**		
h=7					
	7	0,53	**0,43**		
h=0					

Altitude above mean sea level =52 m

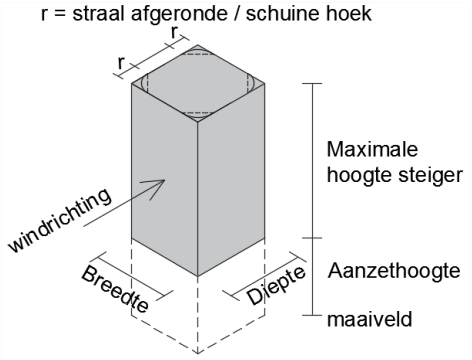
Closest distance to the sea upwind = 10 km

Force coefficient rounded / bevelled corners

According to NEN-EN 1991-1-4 & NA; Hfd 7.6 2021V1.00

General conditions

- b	=	Width	=	7	m	m
- d	=	Depth	=	7	m	m
- a	=	Start height	=	0	m	m
- h	=	Scaffold height	=	24,4	m	m
- r	=	Radius corner	=	1,2	m	m



$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = The force coefficient of rectangular sections with sharp corners and without free-end flow.
Ψr = The reduction factor for square sections with rounded corners.
Ψλ = The end-effect factor for elements with free-end flow.

Determine force coefficient Cf,0
- Depth / Width; d/b = 1,00
- Force coefficient Cf,0 = **2,10**

Determine reduction factor Ψr
- Radius / Width r/b = 0,17
- Reductution factor Ψr = **0,57**

Determine end-effect factor Ψλ
- Scaffold height = 24,4
- Polygonal section
- Netting 90% / Sheeting, around
- solidity ratio ϕ = 1,0
- slenderness λ = 6,4
- end-effect factor Ψλ = **0,66**

$$C_f = C_{f,10} \times \Psi_r \times \Psi_\lambda$$

Cf = 2,1 x 0,57 x 0,66

Cf rounded	=	**0,79**	***72%***

Factor bevelled versus rounded = *1,128*

Cf bevelled	=	**0,89**	***81%***

The '%' is applied in comparison with Cp = 1.10

Overall 19% reduction due to influence chamfered corners & roofs!!