CIVIL AND STRUCTURAL CONSULTING ENGINEERS

STRUCTURAL CALCULATIONS

Client: Leeds Federated Housing Association

Project Name: 17 Poplar Close

Title: Structural Calculations

Document ref: 00.21166-ACE-ZZ-ZZ-CA-S-0001

Date: 30/05/2022

Revision	Suitability	Date	Author	Checked	Approved	Description
P1	S2	May 22	TH	BL	PG	Initial Issue

Leeds
Adept Consulting Engineers Ltd,
1912 Mill, Sunny Bank Mills
Leeds, LS28 5UJ
Tel: 0113 239 4518

Manchester
Adept Consulting Engineers Ltd,
4th Floor, 7 St James Square
Manchester, M2 6DN
Tel: 0161 627 7383

London
Adept Consulting Engineers Ltd,
85 Tottenham Court Road,
London, W1T 4TQ
Tel: 020 3287 6677

Sheffield
Adept Consulting Engineers Ltd,
Courtwood House, Silver Head Street
Sheffield, S1 2DD
Tel: 0114 279 2795

CONTENTS

DESIGN PHILOSOPHY

Description of Scheme & Use:

This package is for the structural calculations for the repairs to a retaining wall at 17 Poplar Close, Bramley, Leeds. The calculations below are to be read in conjunction with report 00.21166-ACE-ZZ-ZZ-RP-S-001. It was found that the brick façade that extended above the existing concrete stem was failing and causing significant movement beyond an acceptable level.

Below are the calculations for a proposed concrete stem, which is to be dowelled into the top of the existing concrete stem. The bricks within the zone of failure should be taken down and replaced with new bricks, tied to the existing and proposed concrete stem.

CODES OF PRACTICE

Loading Codes:	Dead and Imposed Loads	BS 6399: Part 1
	Roof Loads	BS 6399: Part 3
	Wind Loads	BS 6399: Part 2
Building Regulations and Codes of Practice:	General	Current Building Regulations
	Reinforced Concrete	BS 8110
	Masonry	BS 5628
	Foundations	BS 8004
Materials:	Concrete	C28/35
	Reinforcement	fy=500N/mm²
	Structural Steel	S355
	Brickwork	Min. 20N/mm² (iii) Mortar
Fire Resistance:		By others
Exposure Conditions:		XC2, XF1, AC-2 (assumed)
Subsoil Conditions, Bearing Pressure and Foundation Type:		Bearing onto existing retaining structure

DESIGN LOADINGS

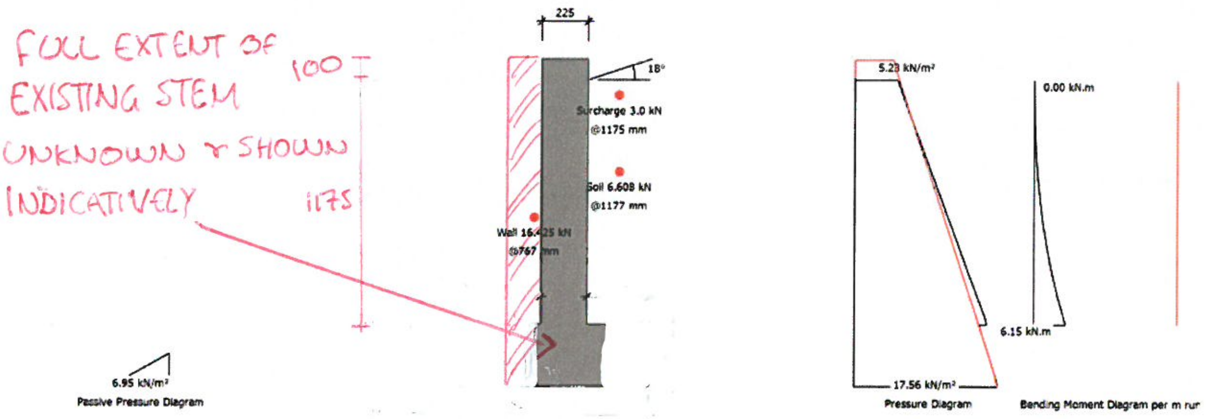
Ground floor		
	Soil/Backfill	18.00 kN/m³
	Concrete Self Weight	24.00 kN/m²
	Surcharge	10.00 kN/m²

Adept Consulting Engineers Ltd.
1912 Mill
Sunny Bank Mills, Farsley
Leeds, West Yorkshire, LS28 5UJ
Tel: (0113) 239 45 18

Cloud d25b0

Job Ref	: 00.21166
Sheet	: Conc rw option /
Made by	: TH
Date	: 07 June 2022 / Ver. 2022.05.26
Checked	: BL
Approved	: PG

MasterKey : Retaining Wall Design to BS 8002 : 1994 and BS 8110 : 1997
Basic RC Retaining Wall
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Soil 18.00, Concrete 24.00
Angles	Embankment 18°
Concrete grade	fcu 35 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 50 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 10.00 kN/m², Fully drained
Unplanned excavation depth	Front of wall 148 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Soil Properties

Bearing pressure	Premissable service pressure @ front 250.00 kN/m², @ back 250.00 kN/m²
Back Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(30)/1.2))) = 19.84°, c = 0.75x200/1.5 = 100 kN/m²
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge, P_p- Passive Earth Pressure

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$+1.00 P_p

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	11.098/23.909	0.464	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+ Rx_{Passive})$	17.515/(141.894+0.533)	0.123	OK

Soil Pressure

Virtual Back (No uplift)	Max(34.807/250, 4.488/250) kN/m²	0.139	OK
Wall Back (No uplift)	Max(33.180/250, 6.115/250) kN/m²	0.133	OK

Adept Consulting Engineers Ltd.
1912 Mill
Sunny Bank Mills, Farsley
Leeds, West Yorkshire, LS28 5UJ
Tel: (0113) 239 45 18

Cloud d25b0

Job Ref	: 00.21166
Sheet	: Conc rw option /
Made by	: TH
Date	: 07 June 2022 / Ver. 2022.05.26
Checked	: BL
Approved	: PG

2

Structural Design

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H10@200 (50 mm) Dist. H10@200 (60 mm)	393 mm²	OK
Leverarm z=fn(d,b,As,fy,Fcu)	170 mm, 1000 mm, 393 mm², 500 N/mm², 35.0 N/mm²	162 mm	
Mr=fn(above,x,x/d)	12 mm, 0.07	27.6 kN.m	
Moment Capacity Check (M/Mr)	M 6.1 kN.m, Mr 27.6 kN.m	0.223	OK
Shear Capacity Check	F 12.6 kN, vc 0.537 N/mm², Fvr 91.3 kN	0.14	OK

Base Top Steel Design

Steel Provided (Cover)	Main H12@175 (50 mm) Dist. H12@175 (62 mm)	646 mm²	OK
Compression Steel Provided (Cover)	Main H12@150 (50 mm) Dist. H12@175 (62 mm)	754 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	244 mm, 1000 mm, 646 mm², 500 N/mm², 35 N/mm²	232 mm	
Mr=fn(above,As',d',x,x/d)	754 mm², 56 mm, 20 mm, 0.08	65.2 kN.m	
Moment Capacity Check (M/Mr)	M 1.5 kN.m, Mr 65.2 kN.m	0.022	OK
Shear Capacity Check	F 9.5 kN, vc 0.514 N/mm², Fvr 125.4 kN	0.08	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H12@150 (50 mm) Dist. H12@175 (62 mm)	754 mm²	OK
Compression Steel Provided (Cover)	Main H12@175 (50 mm) Dist. H12@175 (62 mm)	646 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	244 mm, 1000 mm, 754 mm², 500 N/mm², 35 N/mm²	232 mm	
Mr=fn(above,As',d',x,x/d)	646 mm², 56 mm, 23 mm, 0.10	76.0 kN.m	
Moment Capacity Check (M/Mr)	M 6.4 kN.m, Mr 76.0 kN.m	0.084	OK
Shear Capacity Check	F 15.4 kN, vc 0.541 N/mm², Fvr 132.0 kN	0.12	OK

Geometry

Wall thickness	=	225	mm
Wall Height	=	1275	mm
Retained height (h)	=	1175	mm

Concrete Propeties

Cube compressive strength	=	35	N/mm^2
Reinforcement Grade	=	500	N/mm^2

Loading

Retained Soil Density	=	18	kN/m^3
Surcharge	=	10	kN/m^2
Max. Soil Slope	=	18	deg.
Angle of back of wall to horizontal	=	90	deg.

When the surface of the soil is not horizontal, the surcharge is to be considered equivalent to an extra height of soil, 'he' placed on top of the soil

he	=	0.584	m

FoS

Dead	=	1.4
Live	=	1.6

Retained Soil Poperties

Take angle of shear resistance	=	30	deg.
Active earth pressure (ka)	=	0.395	

Horizontal Forces (kN/m run)		SLS	ULS
Soil (total active thrust)	=	4.91	
Soil (horizontal component)	=	4.67	6.53
Surcharge	=	4.15	6.64
Total		8.82	**13.17**

Bending Moment (kNm/m run)	HF (kN/m)	LA (m)	BM (kNm/m)
Soil	6.53	0.39	2.56
Surcharge	6.64	0.59	3.90
Total			**6.46**

Reinforcement Design (Bending)

BM @ interface	6.46	kNm/m	
Cover	50	mm	
Check min reinforcement	292.5	mm^2/m	(0.0013xArea)
Try A393 mesh	393	mm^2/m	

Effective Depth (d)	=	160	mm	
width, b	=	1000	mm	
M/bd^2fcu	=	0.007		
Z	=	152.00	mm	(0.95d)
As req'd	=	97.71	mm^2/m	
	<	393	mm^2/m	OK
Mc	=	25.99	kNm/m	
Utilisation	=	0.249		

Provide A393 mesh, each face 50mm cover

Reinforcement Design (Shear)

Horizontal shear force at interface	=	13.17	kN/m
shear stress v	=	0.082	N/mm^2
100As/bd	=	0.246	
$400/d^{0.25}$	=	1.257	
Material Factor	=	1.25	
Strength Enhancement	=	1.119	
Concrete resistance, vc	=	0.56	N/mm^2
Utilisation	=	0.148	

No links required

Dowel Design

Determine forces in dowel based on 200mm spacing.

Distance from soil face of wall to dowel centre		85	mm	
Effective depth, d	=	140	mm	
Lever Arm	=	133	mm	(0.95d)
Dowel Diameter	=	16	mm	
Horizontal shear	=	2.63	kN	
Tension	=	9.71	kN	

Conservatively assume the following properties for existing concrete...
Grade - C25/30
Cracked
No reinforcement included to control splitting
Min Width 225 mm

fischer fixings UK Ltd

Whitely Road; Hithercroft Industrial Estate
Wallingford; Oxfordshire; OX10 9AT
Phone: 44-(0)-1491 827900
Fax: 44-(0)- 1491 827953
technical@fischer.co.uk
www.fischer.co.uk

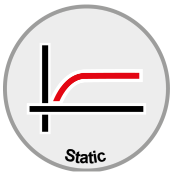
Design Specifications

Anchor

Anchor system	fischer Injection system FIS V
Injection resin	FIS V 360 S
Fixing element	Rebar Ø 16 mm, Property Class f_{yk} = 500 N/mm²
Calculated anchorage depth	225 mm
Design Data	Anchor design in Concrete according European Technical Assessment ETA-02/0024, Option 1, Issued 13/05/2020

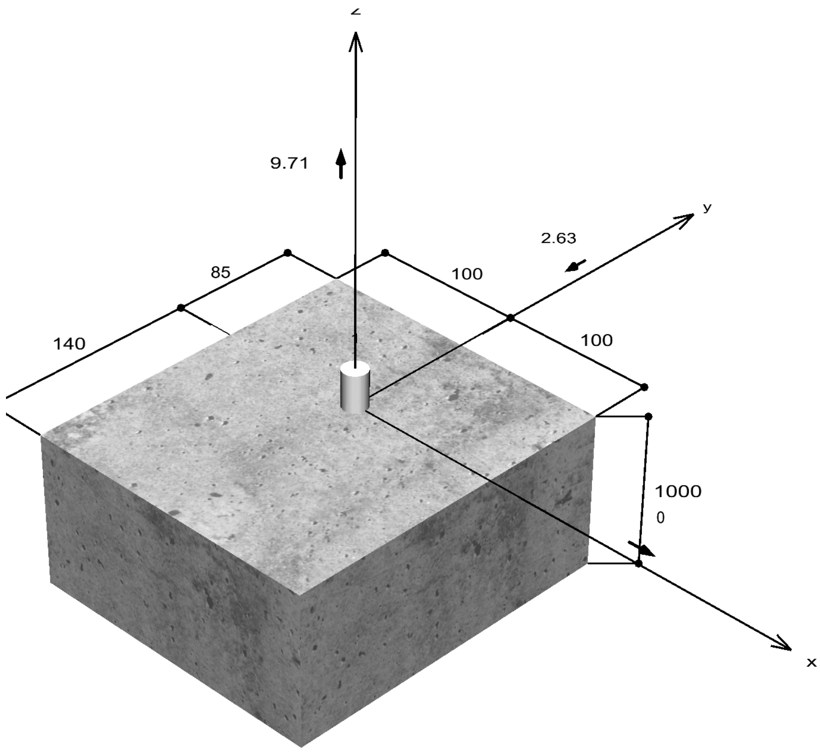
Geometry / Loads / Scale units

mm, kN, kNm



Value of design actions (including

partial safety factor for the load)



Not drawn to scale

Input data

Design method	Design Method EN1992-4:2018 bonded fastener
Base material	C25/30, EN 206
Concrete condition	Cracked, dry hole
Temperature range	24 °C long term temperature, 40 °C short term temperature
Reinforcement	No or standard reinforcement. No edge reinforcement. Without reinforcement against splitting
Drilling method	Hammer drilling
Installation type	Pre-positioned installation
Type of loading	Permanent-Transient/Static

Design actions *)

#	N_{Ed} kN	$V_{Ed,x}$ kN	$V_{Ed,y}$ kN	$M_{Ed,x}$ kNm	$M_{Ed,y}$ kNm	$M_{T,Ed}$ kNm	Type of loading
1	9.71 (9.71)	0.00	-2.63	0.00	0.00	0.00	Permanent-Transient/Static

*) The required partial safety factors for actions are included
The value in brackets shows the sustained load part.

Resulting anchor forces

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	9.71	2.63	0.00	-2.63

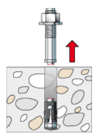
Resistance to tension loads

Proof	Action kN	Capacity kN	Utilisation β_N %
Steel failure *	9.71	78.96	12.3
Combined pull-out and concrete cone failure	9.71	11.77	82.5
Concrete cone failure	9.71	11.72	**82.9**
Splitting failure	9.71	14.17	68.5

* Most unfavourable anchor

Steel failure

$$N_{Ed} \leq \frac{N_{Rk,s}}{\gamma_{Ms}} \quad (N_{Rd,s})$$

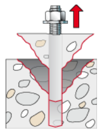


$$N_{Rk,s} = A_S \cdot f_{uk} = 201.0mm^2 \cdot 550.0N/mm^2 = 110.55kN$$ Eq. (5.1)

$N_{Rk,s}$ kN	γ_{Ms}	$N_{Rd,s}$ kN	N_{Ed} kN	$\beta_{N,s}$ %
110.55	1.40	78.96	9.71	12.3

Anchor no.	$\beta_{N,s}$ %	Group N°	Decisive Beta
1	12.3	1	$\beta_{N,s;1}$

Combined pull-out and concrete cone failure



$$N_{Ed} \leq \frac{N_{Rk,p}}{\gamma_{Mp}}$$ **($N_{Rd,p}$)**

$$N_{Rk,p} = N^0_{Rk,p} \cdot \frac{A_{p,N}}{A^0_{p,N}} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np}$$ Eq. (7.13)

$$N_{Rk,p} = 34.88kN \cdot \frac{45{,}000mm^2}{78{,}400mm^2} \cdot 0.882 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 17.66kN$$

$$N^0_{Rk,p} = \Psi_{sus} \cdot \pi \cdot d \cdot h'_{ef} \cdot \tau_{Rk} = 0.60 \cdot \pi \cdot 16mm \cdot 220mm \cdot 5.3N/mm^2 = 34.88kN$$ Eq. (7.14)

$$\Psi_{sus} = \Psi^0_{sus} + 1 - \alpha_{sus} = 0.60 + 1 - 1.00 = 0.60$$ Eq. (7.14b)

$$\alpha_{sus} = 1.00 > \Psi^0_{sus} = 0.60$$

$$s_{cr,Np} = \frac{h'_{ef}}{h_{ef}} \cdot min\left(7.3 \cdot d \cdot \left(\Psi_{sus} \cdot \tau_{Rk,ucr}\right)^{0.5}; 3 \cdot h_{ef}\right)$$ Eq. (7.15)

$$s_{cr,Np} = \frac{220mm}{225mm} \cdot min\left(7.3 \cdot 16mm \cdot \left(0.60 \cdot 10.0N/mm^2\right)^{0.5}; 3 \cdot 225mm\right) = 280mm$$

$$c_{cr,Np} = \frac{S_{cr,Np}}{2} = \frac{280mm}{2} = 140mm$$ Eq. (7.16)

$$\Psi_{s,Np} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} = 0.7 + 0.3 \cdot \frac{85mm}{140mm} = 0.882 \leq 1$$ Eq. (7.20)

$$\Psi_{g,Np} = max\left(1; \Psi^0_{g,Np} - \sqrt{\frac{s}{s_{cr,Np}}} \cdot \left(\Psi^0_{g,Np} - 1\right)\right) = 1.000 - \sqrt{\frac{0mm}{280mm}} \cdot \left(1.000 - 1\right) = 1.000 \geq 1$$ Eq. (7.17)

$$\Psi^0_{g,Np} = max\left(1; \sqrt{n} - \left(\sqrt{n} - 1\right) \cdot \left(\frac{\tau_{Rk}}{\tau_{Rk,c}}\right)^{1.5}\right)$$ Eq. (7.18)

$$\Psi^0_{g,Np} = max\left(1; \sqrt{1} - \left(\sqrt{1} - 1\right) \cdot \left(\frac{5.3N/mm^2}{11.4N/mm^2}\right)^{1.5}\right) = 1.000 \geq 1$$

$$\tau_{Rk,c} = \frac{k_3}{\pi \cdot d}\sqrt{h'_{ef} \cdot f_{ck}} = \frac{7.7}{3.14 \cdot 16mm}\sqrt{220mm \cdot 25.0N/mm^2} = 11.4N/mm^2$$ Eq. (7.19)

$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2e_n}{s_{cr,Np}}} = \Psi_{ec,Npx} \cdot \Psi_{ec,Npy} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.21)

$$\Psi_{ec,Npx} = \frac{1}{1 + \frac{2 \cdot 0mm}{280mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Npy} = \frac{1}{1 + \frac{2 \cdot 0mm}{280mm}} = 1.000 \leq 1$$

$$\Psi_{re,Np} = 1.000$$ Eq. (7.5)

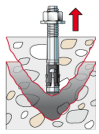
$$h'_{ef} = \frac{c_{max}}{c_{cr,N}} \cdot h_{ef} = \frac{140mm}{143mm} \cdot 225mm = 220mm$$ Eq. (7.8)

$N_{Rk,p}$ kN	γ_{Mp}	$N_{Rd,p}$ kN	N_{Ed} kN	$\beta_{N,p}$ %
17.66	1.50	11.77	9.71	82.5

Anchor no.	$\beta_{N,p}$ %	Group N°	Decisive Beta
1	82.5	1	$\beta_{N,p;1}$

Concrete cone failure

$$N_{Ed} \le \frac{N_{Rk,c}}{\gamma_{Mc}} \quad (\mathbf{N_{Rd,c}})$$



$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \cdot \Psi_{M,N}$$ Eq. (7.1)

$$N_{Rk,c} = 34.71kN \cdot \frac{45{,}000mm^2}{78{,}400mm^2} \cdot 0.882 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 17.58kN$$

$$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h'^{1.5}_{ef} = 7.7 \cdot \sqrt{25.0N/mm^2} \cdot \left(93mm\right)^{1.5} = 34.71kN$$ Eq. (7.2)

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} = 0.7 + 0.3 \cdot \frac{85mm}{140mm} = 0.882 \le 1$$ Eq. (7.4)

$$\Psi_{re,N} = 1.000$$ Eq. (7.5)

$$h'_{ef} = \frac{c_{max}}{c_{cr,N}} \cdot h_{ef} = \frac{140mm}{338mm} \cdot 225mm = 93mm$$ Eq. (7.8)

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_n}{s_{cr,N}}} \Longrightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \le 1$$ Eq. (7.6)

$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 0mm}{280mm}} = 1.000 \le 1 \qquad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 0mm}{280mm}} = 1.000 \le 1$$

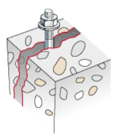
$$\Psi_{M,N} = 1.00 \ge 1$$ Eq. (7.7)

$N_{Rk,c}$ kN	γ_{Mc}	$N_{Rd,c}$ kN	N_{Ed} kN	$\beta_{N,c}$ %
17.58	1.50	11.72	9.71	82.9

Anchor no.	$\beta_{N,c}$ %	Group N°	Decisive Beta
1	82.9	1	$\beta_{N,c;1}$

Splitting failure due to loading

$$N_{Ed} \le \frac{N_{Rk,sp}}{\gamma_{Msp}} \quad (\mathbf{N_{Rd,sp}})$$



$$N_{Rk,sp} = N^0_{Rk,sp} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \cdot \Psi_{h,sp}$$ Eq. (7.23)

$$N_{Rk,sp} = 34.71kN \cdot \frac{45{,}000mm^2}{78{,}400mm^2} \cdot 0.882 \cdot 1.000 \cdot 1.000 \cdot 1.210 = 21.26kN$$

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} = 0.7 + 0.3 \cdot \frac{85mm}{140mm} = 0.882 \leq 1$$ Eq. (7.4)

$$\Psi_{re,N} = 1.000$$ Eq. (7.5)

$$h'_{ef} = \frac{c_{max}}{c_{cr,N}} \cdot h_{ef} = \frac{140mm}{225mm} \cdot 225mm = 140mm$$ Eq. (7.8)

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_n}{s_{cr,sp}}} = \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.6)

$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 0mm}{280mm}} = 1.000 \leq 1 \qquad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 0mm}{280mm}} = 1.000 \leq 1$$

$$\Psi_{h,sp} = min\left(\left(\frac{h}{h_{min}}\right)^{2/3} ; max\left(1; \left(\frac{h_{ef} + 1.5\ c_1}{h_{min}}\right)^{2/3}\right) ; 2\right)$$ Eq. (7.24)

$$\Psi_{h,sp} = min\left(\left(\frac{1{,}000mm}{265mm}\right)^{2/3} ; max\left(1; \left(\frac{225mm + 1.5 \cdot 85mm}{265mm}\right)^{2/3}\right) ; 2\right) = 1.210$$

$N_{Rk,sp}$ kN	γ_{Msp}	$N_{Rd,sp}$ kN	N_{Ed} kN	$\beta_{N,sp}$ %
21.26	1.50	14.17	9.71	68.5

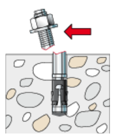
Anchor no.	$\beta_{N,sp}$ %	Group N°	Decisive Beta
1	68.5	1	$\beta_{N,sp;1}$

Resistance to shear loads

Proof	Action kN	Capacity kN	Utilisation β_V %
Steel failure without lever arm *	2.63	36.85	7.1
Concrete pry-out failure	2.63	23.44	11.2
Concrete edge failure	2.63	7.33	**35.9**

* Most unfavourable anchor

Steel failure without lever arm



$$V_{Ed} \leq \frac{V_{Rk,s}}{\gamma_{Ms}}$$ **($V_{Rd,s}$)**

$$V_{Rk,s} = k_7 \cdot V^0_{Rk,s} = 1.00 \cdot 55.28kN = 55.28kN$$ Eq. (7.35)/ (7.36)

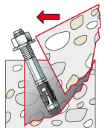
$$V^0_{Rk,s} = k_6 \cdot A_S \cdot f_{uk} = 0.50 \cdot 201.0mm^2 \cdot 550.0N/mm^2 = 55.28kN$$ Eq. (7.34)

$V_{Rk,s}$ kN	γ_{Ms}	$V_{Rd,s}$ kN	V_{Ed} kN	β_{Vs} %
55.28	1.50	36.85	2.63	7.1

Anchor no.	β_{Vs} %	Group N°	Decisive Beta
1	7.1	1	$\beta_{Vs;1}$

Concrete pry-out failure

$$V_{Ed} \leq \frac{V_{Rk,cp}}{\gamma_{Mc}}$$ **($V_{Rd,cp}$)**



$$V_{Rk,cp} = k_8 \cdot N_{Rk,c} = 2 \cdot 17.58kN = 35.15kN$$ Eq. (7.39c)

$$N_{Rk,c} = N^0_{Rk,c} \cdot \frac{A_{c,N}}{A^0_{c,N}} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \cdot \Psi_{M,N}$$ Eq. (7.1)

$$N_{Rk,c} = 34.71kN \cdot \frac{45{,}000mm^2}{78{,}400mm^2} \cdot 0.882 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 17.58kN$$

$$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h'^{1.5}_{ef} = 7.7 \cdot \sqrt{25.0N/mm^2} \cdot \left(93mm\right)^{1.5} = 34.71kN$$ Eq. (7.2)

$$\Psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} = 0.7 + 0.3 \cdot \frac{85mm}{140mm} = 0.882 \leq 1$$ Eq. (7.4)

$$\Psi_{re,N} = 1.000$$ Eq. (7.5)

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_n}{s_{cr,N}}} \Longrightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \leq 1$$ Eq. (7.6)

$$\Psi_{M,N} = 1.00 \geq 1$$ Eq. (7.7)

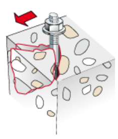
$$h'_{ef} = \frac{c_{max}}{c_{cr,N}} \cdot h_{ef} = \frac{140mm}{338mm} \cdot 225mm = 93mm$$ Eq. (7.8)

$V_{Rk,cp}$ kN	γ_{Mcp}	$V_{Rd,cp}$ kN	V_{Ed} kN	$\beta_{V,cp}$ %
35.15	1.50	23.44	2.63	11.2

Anchor no.	$\beta_{V,cp}$ %	Group N°	Decisive Beta
1	11.2	1	$\beta_{V,cp;1}$

Concrete edge failure

$$V_{Ed} \leq \frac{V_{Rk,c}}{\gamma_{Mc}}$$ **($V_{Rd,c}$)**



$$V_{Rk,c} = V^0_{Rk,c} \cdot \frac{A_{c,V}}{A^0_{c,V}} \cdot \Psi_{s,V} \cdot \Psi_{h,V} \cdot \Psi_{\alpha,V} \cdot \Psi_{ec,V} \cdot \Psi_{re,V}$$ Eq. (7.40)

$$V_{Rk,c} = 27.39kN \cdot \frac{42{,}000mm^2}{88{,}200mm^2} \cdot 0.843 \cdot 1.000 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 10.99kN$$

$$V^0_{Rk,c} = k_9 \cdot d^\alpha \cdot l_f^\beta \cdot \sqrt{f_{ck}} \cdot c_1^{1.5}$$ Eq. (7.41)

$$V^0_{Rk,c} = 1.7 \cdot \left(16mm\right)^{0.117} \cdot \left(192mm\right)^{0.065} \cdot \sqrt{25.0N/mm^2} \cdot \left(140mm\right)^{1.5} = 27.39kN$$

$$\alpha = 0.1 \cdot \sqrt{\frac{l_f}{c_1}} = 0.1 \cdot \sqrt{\frac{192mm}{140mm}} = 0.117 \qquad \beta = 0.1 \cdot \left(\frac{d}{c_1}\right)^{0.2} = 0.1 \cdot \left(\frac{16mm}{140mm}\right)^{0.2} = 0.065$$ Eq. (7.42/7.43)

$$\Psi_{s,V} = 0.7 + 0.3 \cdot \frac{c_2}{1.5c_1} = 0.7 + 0.3 \cdot \frac{100mm}{1.5 \cdot 140mm} = 0.843 \leq 1$$ Eq. (7.45)

$$\Psi_{h,V} = max\left(1; \sqrt{\frac{1.5c_1}{h}}\right) = max\left(1; \sqrt{\frac{1.5 \cdot 140mm}{1{,}000mm}}\right) = 1.000 \geq 1$$ Eq. (7.46)

$$\Psi_{\alpha,V} = \sqrt{\frac{1}{\left(cos\ \alpha_V\right)^2 + \left(0.5 \cdot sin\ \alpha_V\right)^2}} = \sqrt{\frac{1}{\left(cos\ 0.0\right)^2 + \left(0.5 \cdot sin\ 0.0\right)^2}} = 1.000 \geq 1$$ Eq. (7.48)

$$\Psi_{ec,V} = \frac{1}{1 + \frac{2}{3}\frac{e_v}{c_1}} = \frac{1}{1 + \frac{2 \cdot 0mm}{3 \cdot 140mm}} = 1.000 \leq 1$$ Eq. (7.47)

$$\Psi_{re,V} = 1.000$$

$V_{Rk,c}$ kN	γ_{Mc}	$V_{Rd,c}$ kN	V_{Ed} kN	$\beta_{V,c}$ %
10.99	1.50	7.33	2.63	35.9

Anchor no.	$\beta_{V,c}$ %	Group N°	Decisive Beta
1	35.9	1	$\beta_{V,c;1}$

Utilization of tension and shear loads

Tension loads	Utilisation βN %
Steel failure *	12.3
Combined pull-out and concrete cone failure	82.5
Concrete cone failure	**82.9**
Splitting failure	68.5

Shear Loads	Utilisation βV %
Steel failure without lever arm *	7.1
Concrete pry-out failure	11.2
Concrete edge failure	**35.9**

* Most unfavourable anchor

Resistance to combined tensile and shear loads

Utilisation steel

$$\beta_{N,s} = \beta_{N,s;1} = 0.12 \leq 1$$
$$\beta_{V,s} = \beta_{Vs;1} = 0.07 \leq 1$$
$$\beta_N^2 + \beta_V^2 = \beta_{N,s;1}^2 + \beta_{Vs;1}^2 = 0.02 \leq 1$$ Eq. (7.55)

Utilisation concrete

Proof successful

$$\beta_{N,c} = \beta_{N,c;1} = 0.83 \leq 1$$
$$\beta_{V,c} = \beta_{V,c;1} = 0.36 \leq 1$$
$$\beta_N^{1.5} + \beta_V^{1.5} = \beta_{N,c;1}^{1.5} + \beta_{V,c;1}^{1.5} = 0.97 \leq 1$$ Eq. (7.56)

Technical remarks

The transmission of the anchor loads to the supports of the concrete member shall be shown for the ultimate limit state and the serviceability limit state; for this purpose, the normal verifications shall be carried out under due consideration of the actions introduced by the anchors. For these verifications the additional provisions given in the current design method shall be taken into account.
As a pre-condition the anchor plate is assumed to be flat when subjected to the actions. Therefore, the plate (if present) must be sufficiently stiff. The C-Fix anchor plate design is based on a proof of stresses and does not allow a statement about the stiffness of the plate. The proof of the necessary stiffness is not carried out by C-Fix.

During the design process, the following hints and warnings were issued:

- The concrete covering of the rebars within the concrete beam to be added cannot be decided by the software.
  Please check according to national regulations and the scheduled exposition class.

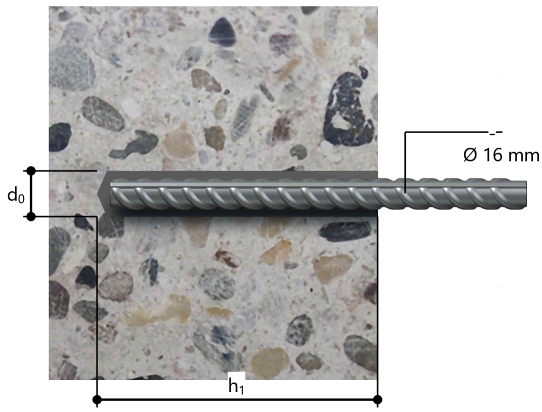
Installation data

Anchor

Anchor system	**fischer Injection system FIS V**	
Injection resin	FIS V 360 S (other cartridge sizes available)	Art.-No. 94405
Fixing element	Rebar Ø 16 mm, Property Class f_{yk} = 500 N/mm²	
Accessories	FIS MR Plus	Art.-No. 545853
	FIS Extension tube 9mm	Art.-No. 48983
	Dispenser FIS DM S	Art.-No. 511118
	Compressed-air cleaning tool	Art.-No. 93286
	compressed air (oil-free), min. 6 bar	By job site.
	BSD 20	Art.-No. 1494
	SDS Chuck with internal thread M8	Art.-No. 530332
	SDS Plus-V II 20/250/300	Art.-No. 531844
	or alternatively	
	FHD Max 20/400/620	Art.-No. 546603
	Hammer drilling with or without suction	

Installation details

Rebar diameter	Ø 16 mm
Drill hole diameter	d_0 = 20 mm
Drill hole depth	h_1 = 225 mm
Calculated anchorage depth	h_{ef} = 225 mm
Drilling method	Hammer drilling
Drill hole cleaning	4 times blowing, 4 times brushing, 4 times blowing required activities according the given instruction in the approval No borehole cleaning required in case of using a hollow drill bit, e.g. fischer FHD.
Installation type	Pre-positioned installation
Volume of resin per drill hole	32 ml/16 scale divisions



CONCRETE SPECIFICATION (BS 8500-1:2015)

In accordance with BS 8500-1:2015

TEDDS calculation version 1.0.14

Element definition

Element description **1**
Intended working life **At least 50 years**
Type of concrete **Reinforced, normal weight**
Maximum aggregate size **20 mm**
Allowance for deviation bet. min & nominal covers Δc_{dev} = **10** mm
Allowance for deviation (XA class) Δc_{dev_s} = **25** mm

Exposure classes

Corrosion induced by carbonation (XC classes)

Type of exposure to air and moisture **Wet, rarely dry**
From BS8500-1 Table A.1
Classification for corrosion induced by carbonation **XC2**

Corrosion induced by chlorides other than from sea water (XD classes)

The concrete is not subject to contact with water containing chlorides.
Therefore there is no XD classification

Corrosion induced by chlorides from sea water (XS classes)

The concrete is not subject to contact with chlorides from sea water.
Therefore there is no XS classification

Freeze/thaw attack (XF classes)

Degree of saturation **Moderate water saturation without de-icing agent**
From BS8500-1 Table A.1
Class for freeze thaw attack **XF1**

Chemical attack (XA classes)

ACEC class **AC-2**
Consequences of failure (Table A.10 note H) **Relatively serious**
Section width t = **200** mm
Hydraulic gradient (Table A.10 note B) **Less than or equal to 5**
From BS8500-1 Table A.10
Design chemical class **DC-2**
No of additional protective measures required APMs = **0**

Concrete requirements and specification

Consistence class **S3**
Air-entrained concrete has not been specified

Minimum allowable nominal covers

For exposure class XC2 (Table A.4) **35 mm**
For DC-class DC-2 (Table A.10) **50 mm**
Specified nominal cover **50 mm**

PASS - The specified nominal cover is adequate

Minimum strength class with 50 mm nominal cover

For exposure class XC2 (Table A.4) **C25/30**

For exposure class XF1 (Table A.9)	**C28/35**
For DC-class DC-2 (Table. A.12)	**C25/30**
Specified strength class	**C28/35**

PASS - The specified strength class is adequate

Maximum water/cement ratio with 50 mm cover and C28/35 concrete

For exposure class XC2 (Table A.4)	**0.65**
For exposure class XF1 (Table A.9)	**0.60**
For DC-class DC-2 with 20mm aggregate (T. A.12)	**0.55**
Specified maximum water/cement ratio	**0.50**

PASS - The specified maximum water cement ratio is adequate

Minimum cement content with 50 mm cover and C28/35 concrete

For exposure class XC2 (Table A.4)	**260 kg/m^3**
For exposure class XF1 (Table A.9)	**280 kg/m^3**
For DC-class DC-2 & w/c ratio of 0.50 (T. A.12)	**340 kg/m^3**
For specified max w/c ratio of 0.50 (Table A.7)	**320 kg/m^3**
Specified minimum cement content	**340 kg/m^3**

PASS - The specified minimum cement content is adequate

Allowable cements/combinations with 50 mm cover and C28/35 concrete

For exposure class XC2 (Table A.4) **All in Table A.6**

For exposure class XF1 (Table A.9) **All in Table A.6**

For DC-2, w/c ratio=0.50, cem content=340 kg/m^3 **IIB-V+SR, IIIA+SR, IIIB+SR, IVB-V, CEM I, CEM I-SR0, CEM I-SR3, IIA-D, IIA-Q, IIA-S, IIA-V, IIB-S, IIB-V, IIIA, IIIB (Table A.12)**

Resultant allowable cement/combinations types **CEM I CEM I-SR0 CEM I-SR3 IIA-D IIA-Q IIA-S IIA-V IIB-S IIB-V IIB+SR IIIA IIIA+SR IIIB IIIB+SR IVB-V**

Designed concrete specification for 1 (50 mm nominal cover)

The concrete shall be produced in accordance with BS8500-2.

Compressive strength class **C28/35**

Maximum water/cement ratio **0.50**

Minimum cement/combination content **340 kg/m^3**

Allowable cement/combinations types **CEM I CEM I-SR0 CEM I-SR3 IIA-D IIA-Q IIA-S IIA-V IIB-S IIB-V IIB+SR IIIA IIIA+SR IIIB IIIB+SR IVB-V (DC-2)**

Maximum aggregate size **20 mm**

Chloride content class **Cl 0,40**

Consistence class **S3**