

**Appendix to report:**

SBJ-33-C5-OON-22-RE-019  
DESIGN OF CABLE STAYED BRIDGE

**Appendix title:**

APPENDIX G – FOUNDATION DESIGN

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## CONCEPT DEVELOPMENT FLOATING BRIDGE E39 BJØRNAFJORDEN

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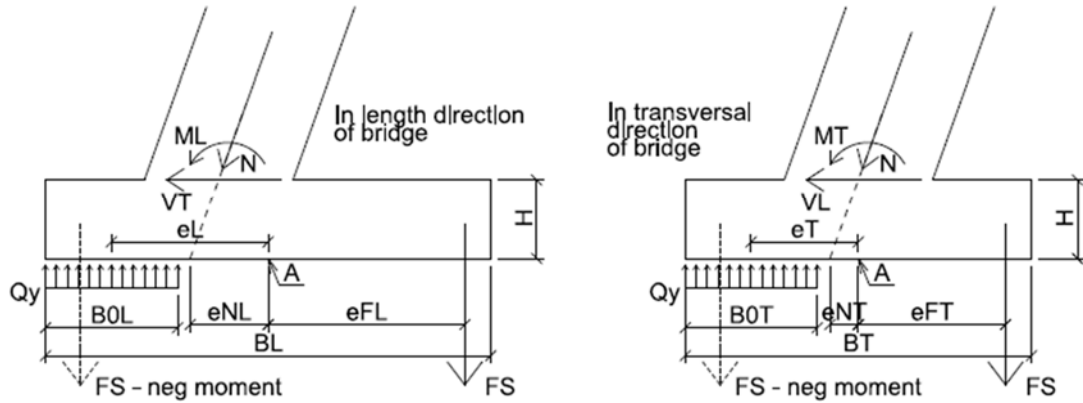
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# 1 INTRODUCTION

Results from the foundation design is presented in this appendix.

## 2 EXAMPLE

The following figure is used to calculate the bridge foundations:



Explanation	Naming convention	Value	Unit
Width foundation, length direction	BL	22	m
Width foundation, transversal direction	BT	15	m
Height of foundation	H	8	m
Eccentricity of normal force	eNL	0.70	m
Eccentricity of normal force	eNT	1.28	m
Density of concrete	GammaBet	25	KN/m <sup>3</sup>
Number of rock anchors	n	6	
Eccentricity of rock anchor, in length	eFL	9.5	m
Eccentricity of rock anchor, in transversal	eFT	6	m
Force single rock anchor	FKar	5022	kN
Reduction coefficient for anchor	GammaStag	0.65	
Reduced force from rock anchor	FDim	3264.3	kN

LoadCombination	N[kN]	VL[kN]	VT[kN]	ML[kNm]	MT[kNm]	YG
Free tower, wind from north	123443	-11192	-13612	-1249961	308081	0.9

Forces from the free-standing tower in construction phase is used as an example:

LoadCombination	N[kN]	VL[kN]	VT[kN]	ML[kNm]	MT[kNm]	YG
Free tower, wind from north	123443	-11192	-13612	-1249961	308081	0.9

Equalibrium around point A is conducted.

#### Without rock anchors

	Without anchors	
Moment around A, in lenth dir	$MLA=ML+VT*H+N*eNL$	-1272787 kNm
Moment around A, in trans dir	$MTA=MT+VL*H+N*eNT$	377115 kNm
Weight of foundation	$Nfund=BL*BT*H*yBet$	66000 kN
Normal force at A	$Na=N+Nfund*YG$	182843.2 kN
Eccentricity of the reaction force	$eL=MLA/NA$	7.0 m
Effective width, length dir	$BOL=BL-2*eL$	8.1 m
Eccentricity of the reaction force	$eT=MTA/NA$	2.1 m
Effective width, transversal dir	$BOT=BOT-2*eT$	10.9 m
Ground pressure	$qy=NA/(BOL*BOT)$	2081.4 kN/m2

Rock anchors: Rock anchor type is 18 strands of 150mm<sup>2</sup> with  $f_{pk}$  of 1860MPa.

V220 chapter 10.5.2.1 gives reduction factor of 0,65.

#### With rock anchors

	With anchors	
Force from rock anchors	$FS=n*FenkDim$	19585.8 kN
Normal force at A	$NA=NA+FS$	202429.0 kN
Moment around A, in lenth dir	$MLA=MLA-FS*eFL$	1086721.7 kNm
Moment around A, in trans dir	$MTA=MTA-FS*eFT$	259600.4 kNm
Eccentricity of the reaction force	$eL=MLA/NA$	5.4 m
Effective width, length dir	$BOL=BL-2*eL$	11.3 m
Eccentricity of the reaction force	$eT=MTA/NA$	1.3 m
Effective width, transversal dir	$BOT=BOT-2*eT$	12.4 m
Ground pressure	$qy=NA/(BOL*BOT)$	1445.3 kN/m2

The goal of the analysis is to keep the Ground pressure( $qy$ ) below 10 000kN/m<sup>2</sup>, this is according to the geology report.

The rest of the analysis can be found in appendix G.

The maximum ground pressure is found to be 3 600kN/m<sup>2</sup>. The foundation size could be reduced in the detailed design phase, when exact allowed ground pressure is clarified.

### 3 FREE STANDING TOWER

LoadCombination	N[kN]	VL[kN]	VT[kN]	ML[kNm]	MT[kNm]	YG
Free tower, wind from north	123443	-11192	-13612	-1249961	308081	0.9
Free tower, wind from south	123920	-11239	-12067	-1077031	309974	0.9
Free tower, wind transversal, leg upstream	121751	-14904	-10641	-844254	484800	0.9
Free tower, wind transversal, leg downstream	142473	-11068	-10511	-844762	336489	0.9
Free tower, wind from north	164537	-14910	-17067	-1522107	409876	1.2
Free tower, wind from south	165014	-14957	-15522	-1349177	411769	1.2
Free tower, wind transversal, leg upstream	162874	-18597	-14129	-1117359	585173	1.2
Free tower, wind transversal, leg downstream	183538	-14792	-13956	-1116863	438352	1.2

Loadcase	NA[kN]	MLA[kNm]	MTA[kNm]	eL[m]	BOL[m]	eT[m]	BOT[m]	Qy[m]
1	2.02E+05	1.09E+06	2.60E+05	5.4	11.3	1.3	12.4	1445.3
2	2.03E+05	9.01E+05	2.62E+05	4.4	13.1	1.3	12.4	1245.4
3	2.01E+05	6.58E+05	4.04E+05	3.3	15.4	2.0	11.0	1185.1
4	2.21E+05	6.43E+05	3.13E+05	2.9	16.2	1.4	12.2	1124.1
5	2.63E+05	1.36E+06	3.84E+05	5.2	11.7	1.5	12.1	1865.2
6	2.64E+05	1.17E+06	3.87E+05	4.4	13.1	1.5	12.1	1666.9
7	2.62E+05	9.31E+05	5.28E+05	3.6	14.9	2.0	11.0	1603.3
8	2.82E+05	9.14E+05	4.38E+05	3.2	15.5	1.6	11.9	1529.1

## 4 FREE STANDING TOWER IN CONSTRUCTION PHASE

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The free-standing tower in construction phase is less critical compared to the full free-standing tower.

## 5 FREE STANDING STAY-CABLE BRIDGE

LoadCombination	N[kN]	VL[kN]	VT[kN]	ML[kNm]	MT[kNm]	YG
Free cable-stayed, 50-year, leg upstream	251421	33860	15669	1194574	321343	1.2
Free cable-stayed, Installation, leg upstream	108451	16921	4695	-501256	245671	1.2
Free cable-stayed, 50-year, leg downstream	293212	28260	15891	1206025	547098	1.2
Free cable-stayed, Installation, leg downstream	131925	-13783	4795	-495514	495514	1.2
Free cable-stayed, 50-year, leg upstream	188748	30123	12615	1006414	424389	0.9
Free cable-stayed, Installation, leg upstream	45091	13184	-2437	-589839	348614	0.9
Free cable-stayed, 50-year, leg downstream	230504	24554	12793	1016524	648768	0.9
Free cable-stayed, Installation, leg downstream	585441	17117	-49732	-68559	-473069	0.9

Loadcase	NA[kN]	MLA[kNm]	MTA[kNm]	eL[m]	BOL[m]	eT[m]	BOT[m]	Qy[m]
1	3.50E+05	1.31E+06	7.98E+05	3.7	14.5	2.3	10.4	2308.7
2	2.07E+05	2.02E+05	4.03E+05	1.0	20.1	1.9	11.1	930.1
3	3.92E+05	1.35E+06	1.03E+06	3.4	15.1	2.6	9.7	2666.4
4	2.31E+05	1.79E+05	4.37E+05	0.8	20.4	1.9	11.2	1006.5
5	2.68E+05	1.05E+06	7.90E+05	3.9	14.1	3.0	9.1	2082.3
6	1.24E+05	3.92E+05	3.94E+05	3.2	15.7	3.2	8.6	915.5
7	3.09E+05	1.09E+06	1.02E+06	3.5	14.9	3.3	8.4	2471.9
8	6.64E+05	-1.28E+05	1.24E+06	-0.2	22.4	1.9	11.3	2637.5



## 6 OPERATIONAL PHASE

LoadCombination	N[kN]	VL[kN]	VT[kN]	ML[kNm]	MT[kNm]	YG
ULS1	280707	-14080	-1801	-2675478	225723	0.9
ULS2	282959	-14245	-246	-2711733	225850	0.9
ULS3	245051	-4760	1589	-2663957	553526	0.9
ULS4	285024	-14396	-4951	-2670495	225788	0.9
ULS5	322655	-25046	-5789	-2689032	-159927	0.9
ULS6	265887	-12996	-5965	-1709934	225101	0.9
ULS7	268139	-13160	-4410	-1746189	225228	0.9
ULS8	230230	-3675	-2575	-1698413	552904	0.9
ULS9	270204	-13311	-9115	-1704951	225165	0.9
ULS10	307835	-23961	-9953	-1723488	-160549	0.9
ULS1	280707	-14080	-1801	-2675478	225723	1.2
ULS2	282959	-14245	-246	-2711733	225850	1.2
ULS3	245051	-4760	1589	-2663957	553526	1.2
ULS4	285024	-14396	-4951	-2670495	225788	1.2
ULS5	322655	-25046	-5789	-2689032	-159927	1.2
ULS6	265887	-12996	-5965	-1709934	225101	1.2
ULS7	322655	-25046	-5789	-2689032	-159927	1.2
ULS8	265887	-12996	-5965	-1709934	225101	1.2
ULS9	268139	-13160	-4410	-1746189	225228	1.2
ULS10	230230	-3675	-2575	-1698413	552904	1.2

Loadcase	NA[kN]	MLA[kNm]	MTA[kNm]	eL[m]	BOL[m]	eT[m]	BOT[m]	Qy[m]
1	359692.8	2308099	356153.86	6.42	9.17	0.99	13.02	3014
2	361944.8	2330344	357853.69	6.44	9.12	0.99	13.02	3046
3	324036.8	2294319	712714.50	7.08	7.84	2.20	10.60	3899
4	364009.8	2325306	359236.31	6.39	9.22	0.99	13.03	3030
5	401640.8	2324309	256514.68	5.79	10.43	0.64	13.72	2807
6	344872.8	1386200	345166.64	4.02	13.96	1.00	13.00	1900
7	347124.8	1408445	346874.48	4.06	13.89	1.00	13.00	1923
8	309215.8	1372421	701734.00	4.44	13.12	2.27	10.46	2252
9	349189.8	1403407	348256.10	4.02	13.96	1.00	13.01	1923
10	386820.8	1402410	246779.47	3.63	14.75	0.64	13.72	1911
11	379492.8	2308099	356153.86	6.08	9.84	0.94	13.12	2940
12	381744.8	2330344	357853.69	6.10	9.79	0.94	13.13	2971
13	343836.8	2294319	712714.50	6.67	8.65	2.07	10.85	3660
14	383809.8	2325306	359236.31	6.06	9.88	0.94	13.13	2958
15	421440.8	2324309	256514.68	5.52	10.97	0.61	13.78	2787
16	364672.8	1386200	345166.64	3.80	14.40	0.95	13.11	1932
17	421440.8	2324309	256514.68	5.52	10.97	0.61	13.78	2787
18	364672.8	1386200	345166.64	3.80	14.40	0.95	13.11	1932
19	366924.8	1408445	346874.48	3.84	14.32	0.95	13.11	1954
20	329015.8	1372421	701734.00	4.17	13.66	2.13	10.73	2244

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