Concept development, floating bridge
E39 Bjørnafjorden

Appendix L – Enclosure 1

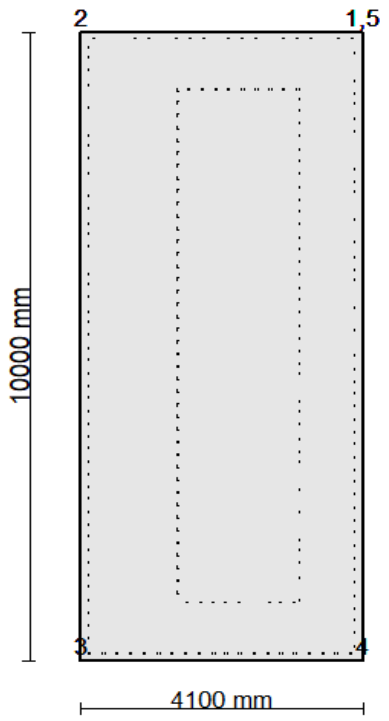
Capacity diagrams

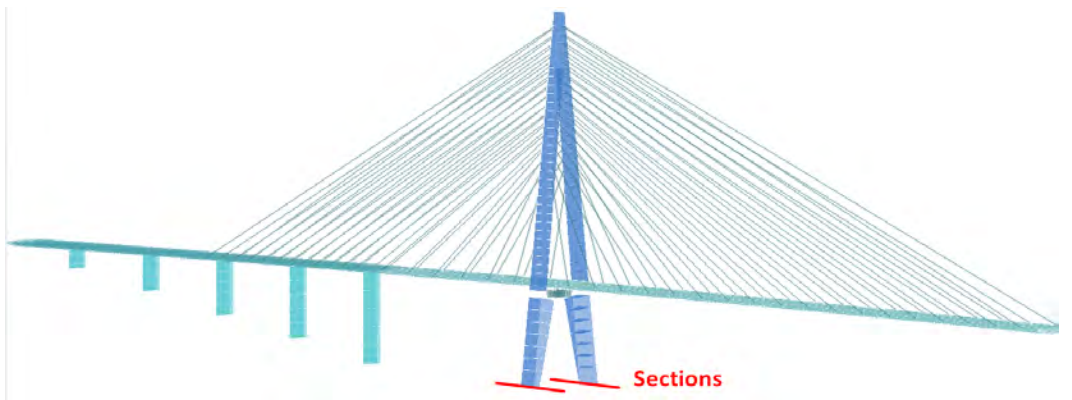
Capacity diagrams

Elevation 0 m

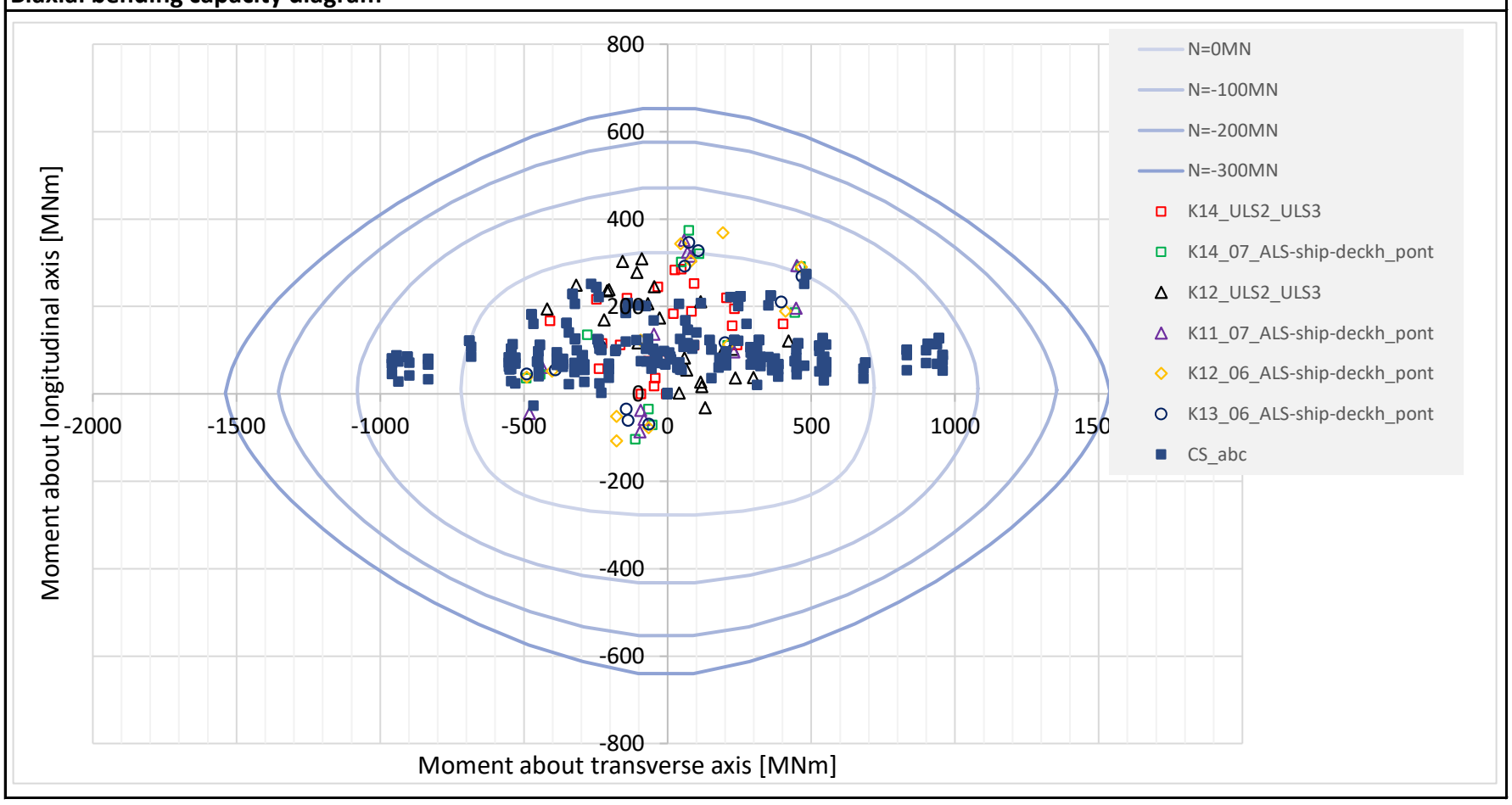
Title	301 Z=0 x*y=10*4.1 massive	
Ac	4.10E+07	mm2
Ix	3.42E+14	mm4
Iy	5.74E+13	mm4
As	3.80E+05	mm2
rho	0.9 %	
	2ø32c200	two layers
Elevation	0	m

Project	Bjørnafjorden phase 5
Date	25.06.2019
By	Petter Buckholm
Models	K11_07 (ULS/ALS)
	K12_06 (ULS/ALS)
	K13_06 (ULS/ALS)
	K14_07 (ULS/ALS)
	C.S. a,b,c, all wind.dir.
	(results dated 24.06.2019)

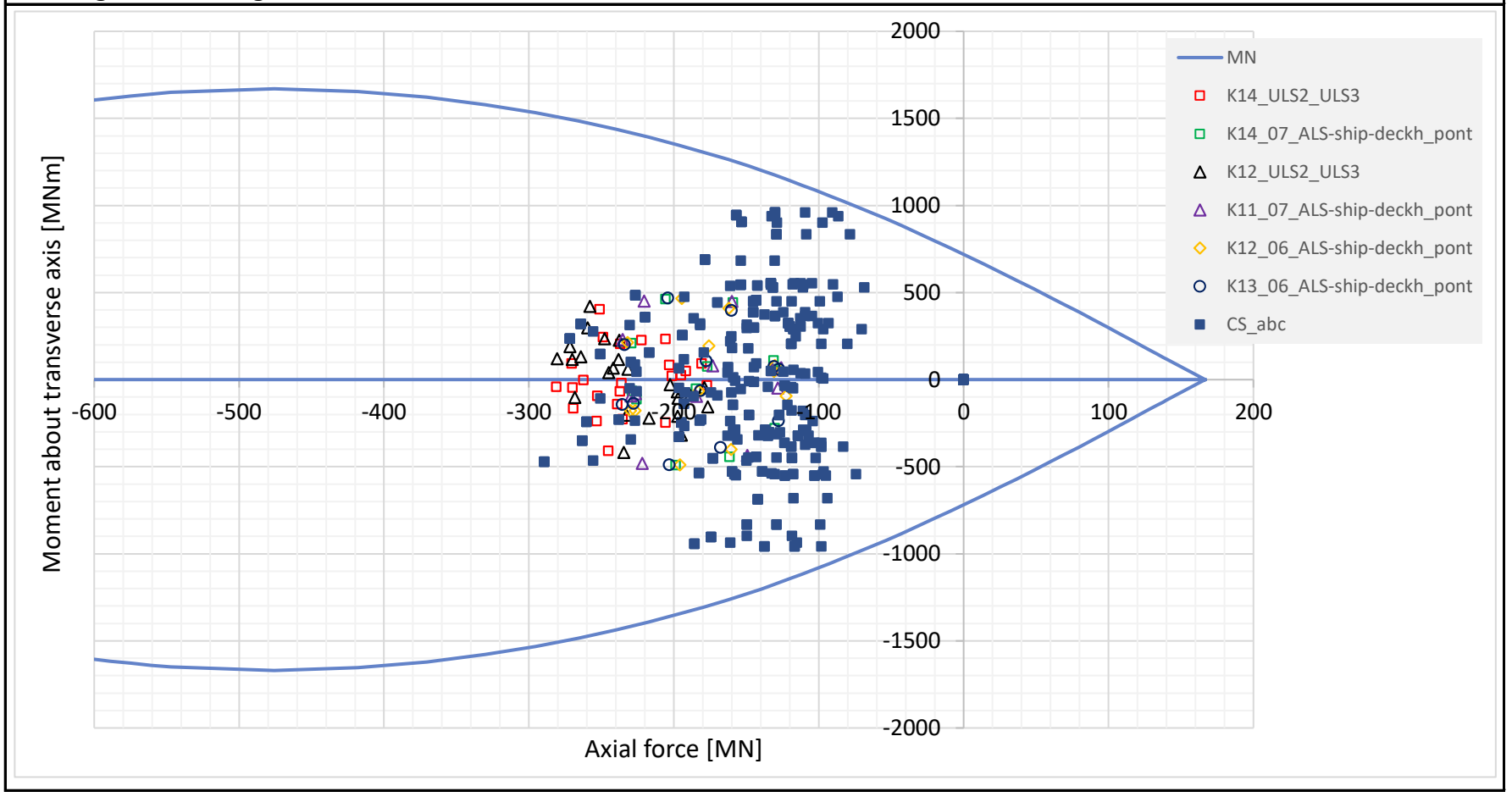




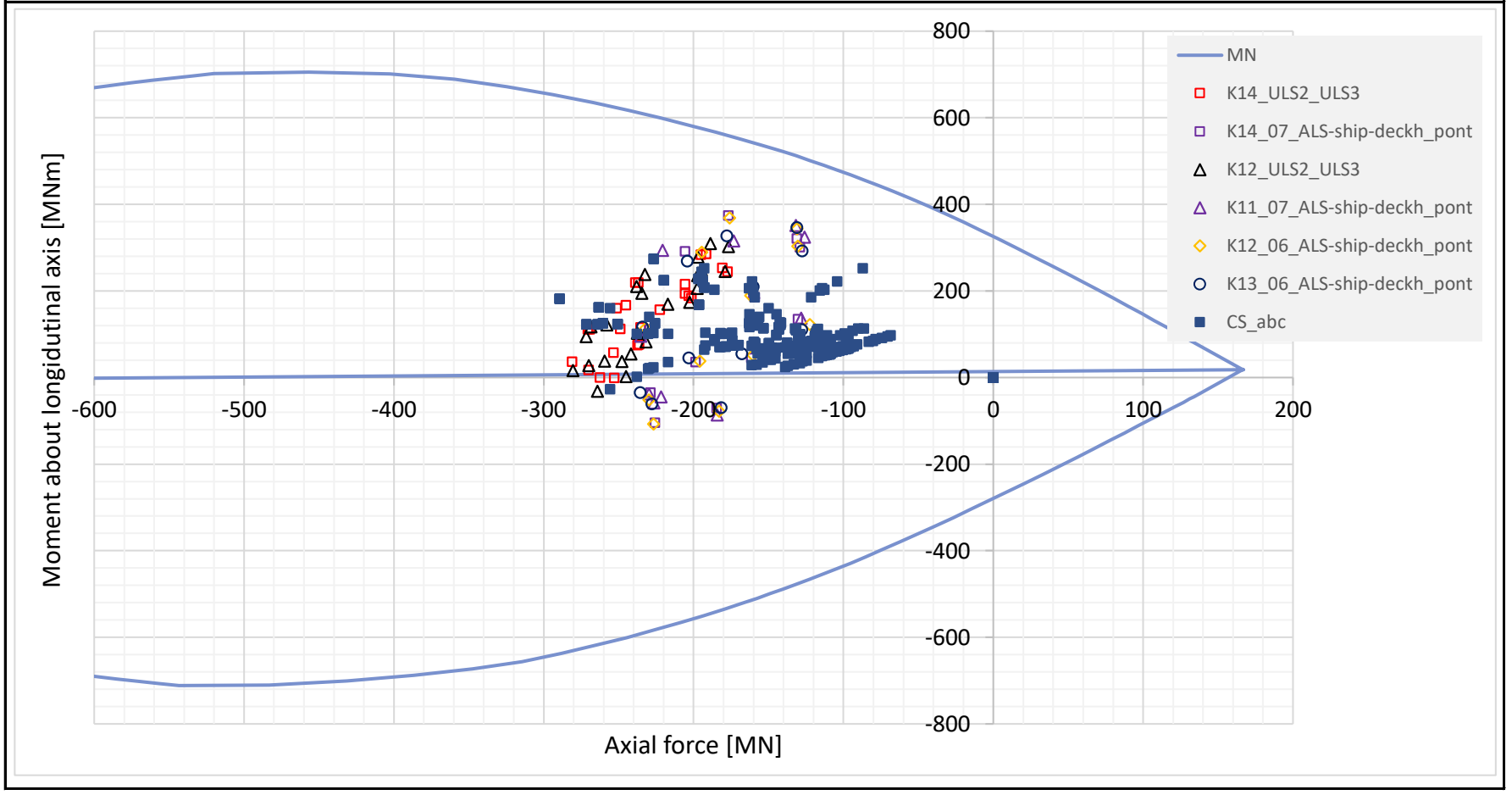
Biaxial bending capacity diagram



MN-diagram - bending about transverse axis



MN-diagram - bending about longitudinal axis

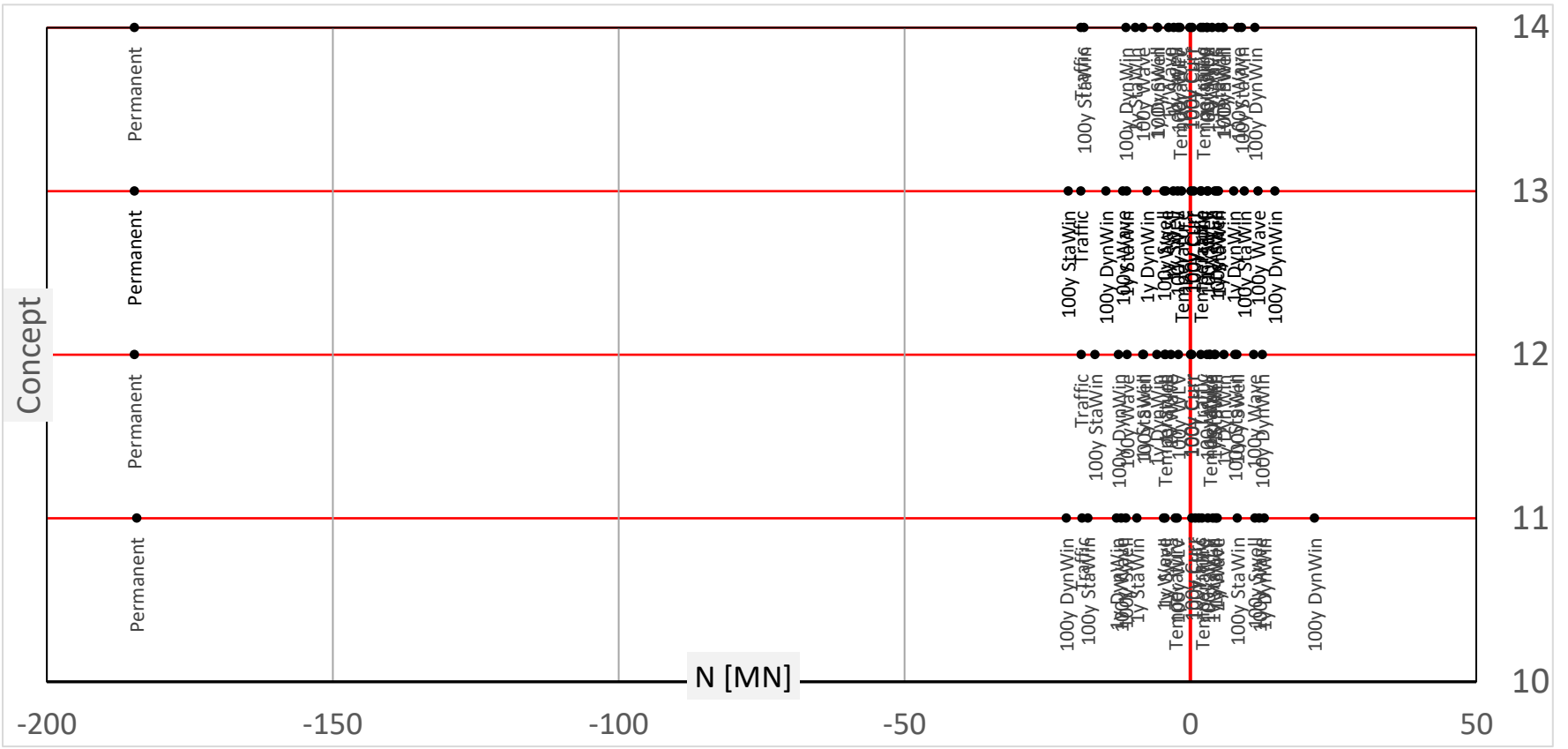


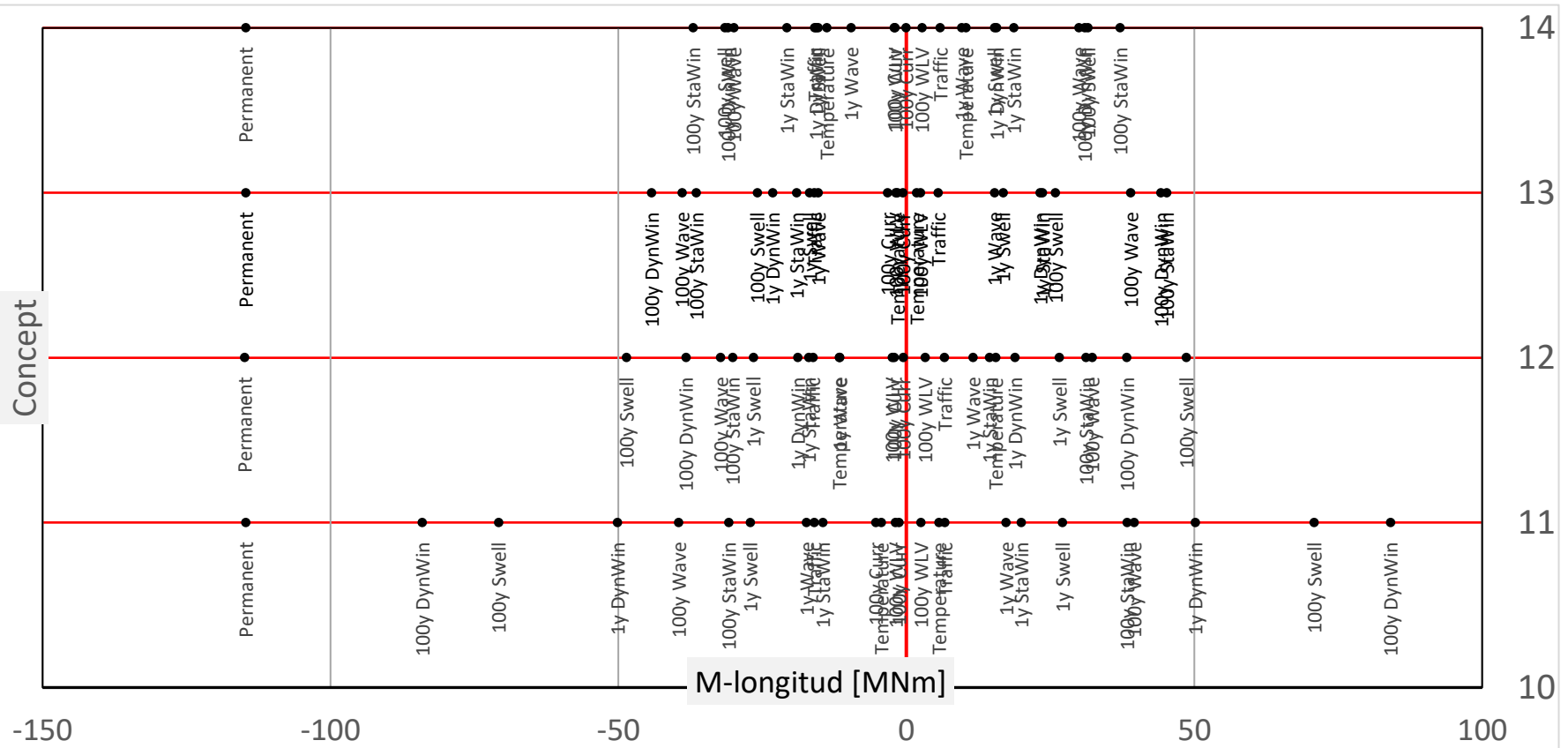
Design loads

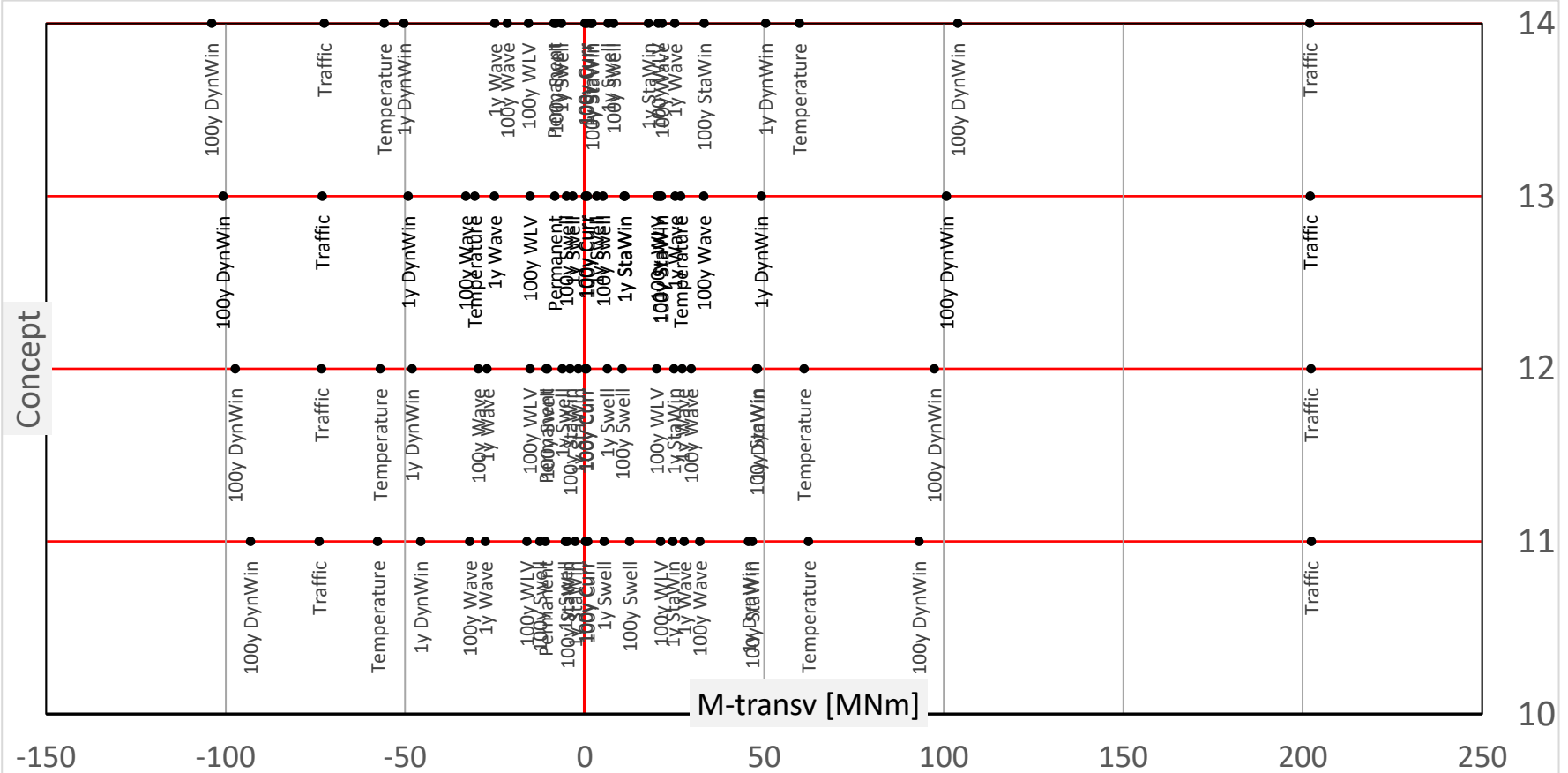
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K14_07	ULS3	Min N	east	-281	-42	36
		Min N	west	-270	-46	17
		Min M longit	east	-195	25	283
		Min M longit	west	-253	-93	-1
		Min M transv	east	-253	-238	57
		Min M transv	west	-206	234	194
		Max N	east	-181	92	252
		Max N	west	-177	-33	244
		Max M longit	east	-262	-4	-1
		Max M longit	west	-192	48	285
		Max M transv	east	-249	242	112
		Max M transv	west	-206	-248	216
		_Worst_Min	east	-251	-252	233
		_Worst_Min	west	-252	253	44
		_Worst_Max	east	-190	244	47
		_Worst_Max	west	-191	-243	225
	ULS2	Min N	east	-270	93	111
		Min N	west	-269	-165	111
		Min M longit	east	-237	205	219
		Min M longit	west	-237	-67	75
		Min M transv	east	-235	-227	115
		Min M transv	west	-222	226	156
		Max N	east	-203	84	189
		Max N	west	-201	21	183
		Max M longit	east	-236	-21	77
		Max M longit	west	-239	-141	219
		Max M transv	east	-251	403	160
		Max M transv	west	-245	-409	167
		_Worst_Min	east	-260	-236	202
		_Worst_Min	west	-262	234	89
		_Worst_Max	east	-205	400	91
		_Worst_Max	west	-206	-406	200
K14_07	ALS-ship-deckh_pont	Min N	east	-229	-66	-35
		Min M longit	east	-226	-112	-105
		Min M transv	east	-199	-491	35
		Max N	east	-129	48	301
		Max M longit	east	-131	110	321
		Max M transv	east	-159	443	185
		Min N	west	-229	209	111
		Min M longit	west	-177	75	374
		Min M transv	west	-206	463	291
		Max N	west	-130	-279	135
		Max M longit	west	-185	-53	-71
		Max M transv	west	-162	-443	44

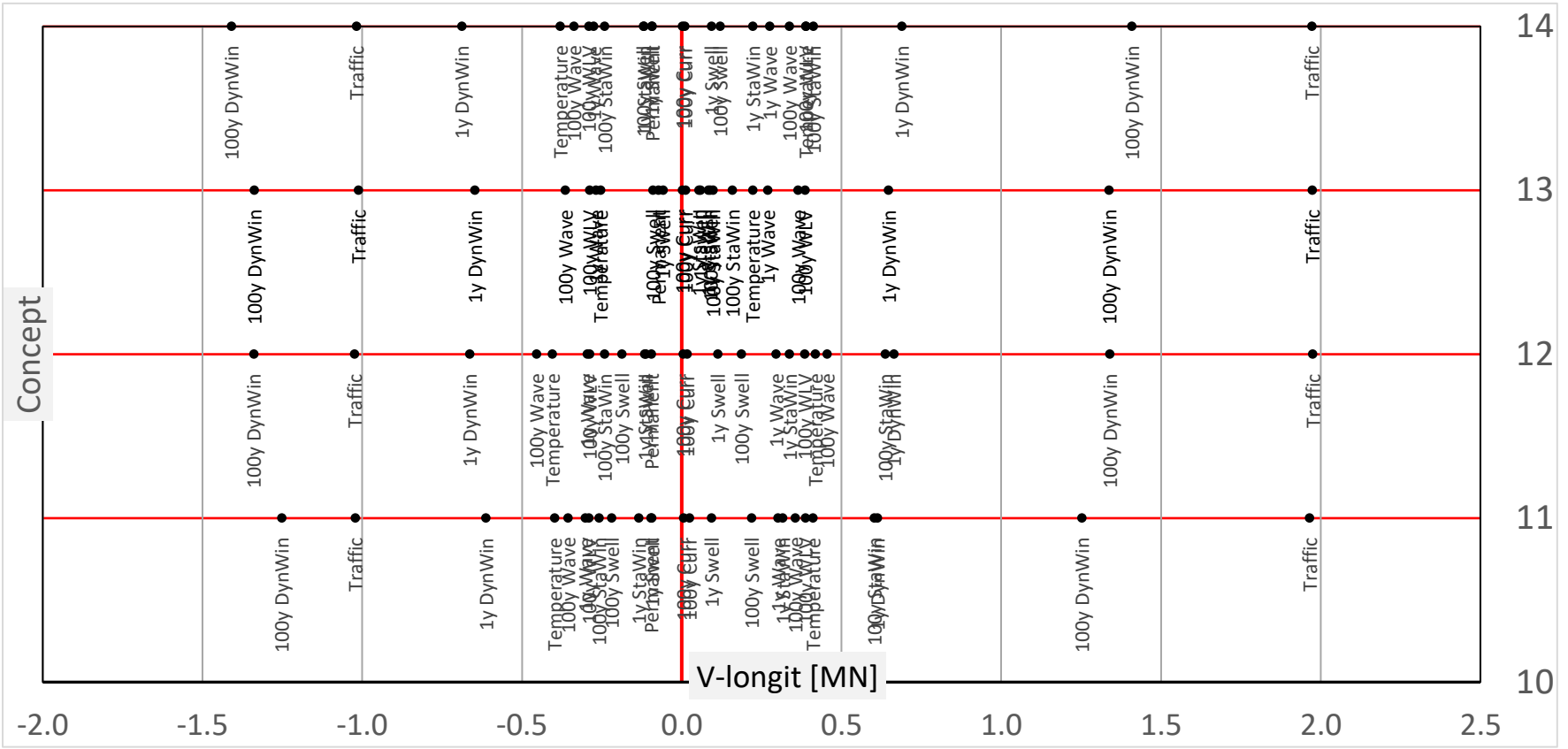
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K12_06	ULS3	Min N	east	-280	119	16
		Min N	west	-270	115	27
		Min M longit	east	-197	-107	278
		Min M longit	west	-245	41	2
		Min M transv	east	-197	-211	236
		Min M transv	west	-248	236	37
		Max N	east	-179	-46	245
		Max N	west	-177	-157	303
		Max M longit	east	-264	131	-32
		Max M longit	west	-189	-90	309
		Max M transv	east	-259	298	38
		Max M transv	west	-195	-318	248
		_Worst_Min	east	-255	-248	261
		_Worst_Min	west	-252	250	14
		_Worst_Max	east	-187	234	14
		_Worst_Max	west	-190	-232	260
	ULS2	Min N	east	-272	190	94
		Min N	west	-268	-103	117
		Min M longit	east	-238	115	210
		Min M longit	west	-232	59	82
		Min M transv	east	-217	-220	169
		Min M transv	west	-238	226	102
		Max N	east	-203	-29	174
		Max N	west	-198	-69	206
		Max M longit	east	-242	66	54
		Max M longit	west	-233	-203	238
		Max M transv	east	-258	420	121
		Max M transv	west	-235	-419	195
		_Worst_Min	east	-263	-232	215
		_Worst_Min	west	-263	229	76
		_Worst_Max	east	-204	390	72
		_Worst_Max	west	-205	-394	220
K11_07	ALS-ship-deckh_pont	Min N	east	-230	-93	-38
		Min M longit	east	-227	-81	-59
		Min M transv	east	-222	-481	-44
		Max N	east	-126	69	324
		Max M longit	east	-132	57	351
		Max M transv	east	-160	448	196
		Min N	west	-235	231	96
		Min M longit	west	-173	79	316
		Min M transv	west	-221	450	294
		Max N	west	-128	-48	137
		Max M strong	west	-184	-96	-87
		Max M weak	west	-149	-436	61
K12_06	ALS-ship-deckh_pont	Min N	east	-230	-177	-52
		Min M longit	east	-227	-177	-107
		Min M transv	east	-196	-490	38
		Max N	east	-130	81	304
		Max M longit	east	-131	46	343
		Max M transv	east	-162	410	189
		Min N	west	-232	212	113
		Min M longit	west	-176	193	368
		Min M transv	west	-195	465	290
		Max N	west	-123	-94	123
		Max M longit	west	-183	-67	-78
		Max M transv	west	-161	-402	52
K13_06	ALS-ship-deckh_pont	Min N	east	-236	-144	-35
		Min M longit	east	-228	-137	-61
		Min M transv	east	-203	-490	45
		Max N	east	-127	60	292
		Max M longit	east	-131	74	346
		Max M transv	east	-160	396	210
		Min N	west	-234	200	116
		Min M longit	west	-178	107	327
		Min M transv	west	-204	468	269
		Max N	west	-128	-236	110
		Max M longit	west	-181	-64	-70
		Max M transv	west	-168	-390	55

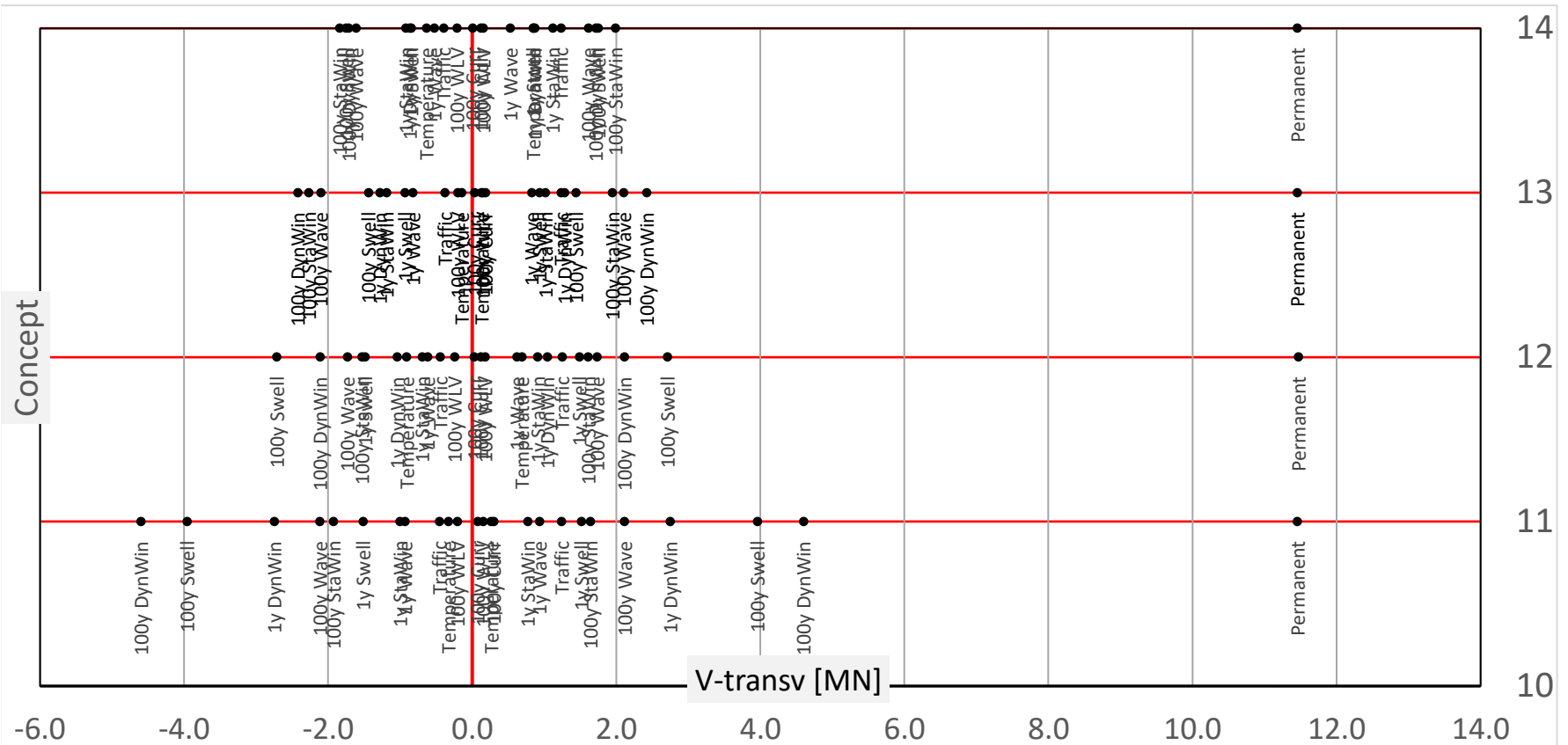
Concept comparson - characteristic load actions - Tower leg east (elevation 0)








Concept
V-longit [MN]
14
13
12
11
10
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5


Concept
V-transv [MN]
14
13
12
11
10
-6.0
-4.0
-2.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0

Construction stages - summary

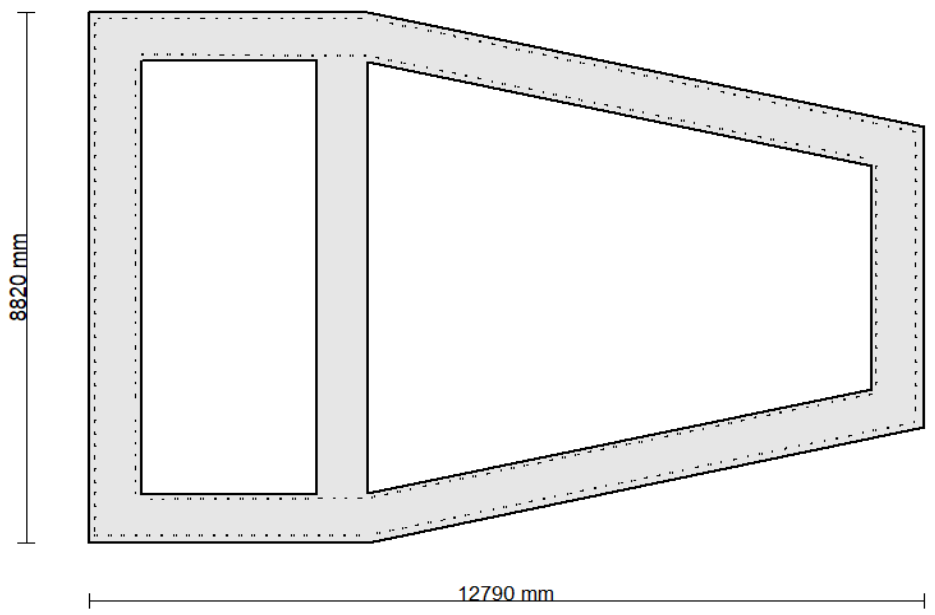
Phase	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
Tower leg west	Phase a	ULS	Max	-70	385	106
			Min	-160	-958	24
	Phase b	ULS	Max	-90	552	127
			Min	-186	-943	28
	Phase c	ULS	Max	-104	276	243
			Min	-289	-473	-28
Tower leg east	Phase a	ULS	Max	-68	958	110
			Min	-158	-385	27
	Phase b	ULS	Max	-86	944	127
			Min	-183	-549	29
	Phase c	ULS	Max	-87	482	274
			Min	-272	-266	2

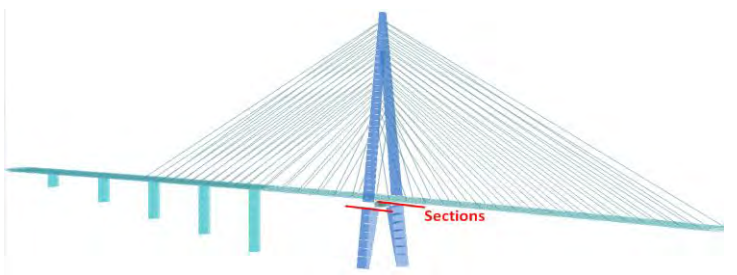
Capacity diagrams

Elevation 52 m

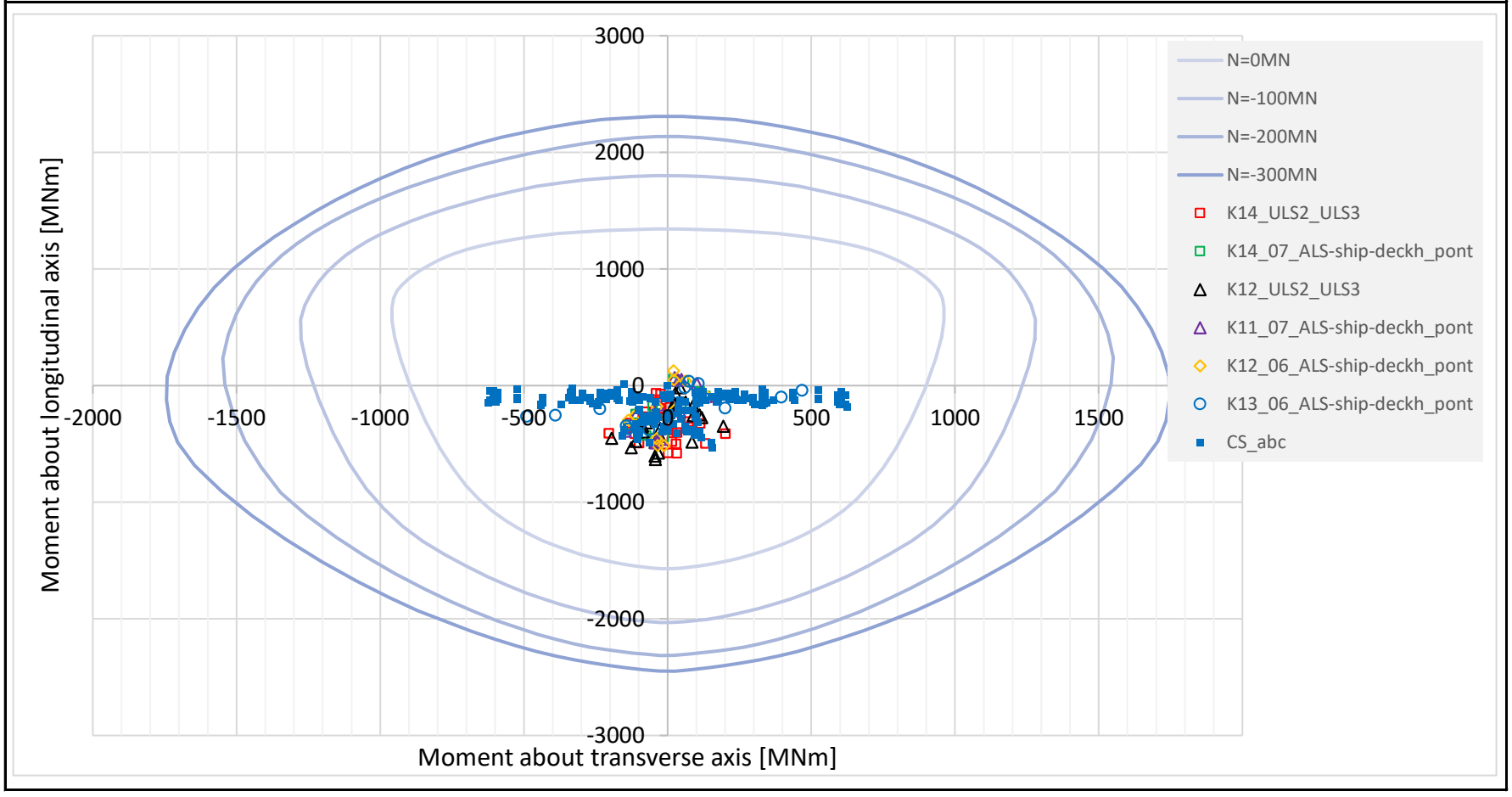
Title	309 Z=52 x*y=8.82*4.28	
Ac	3.52E+07	mm2
Ix	2.98E+14	mm4
Iy	6.01E+14	mm4
As	5.84E+05	mm2
rho	1.7 %	
	2ø32c200	two layers
Elevation	52	m

Project	Bjørnafjorden phase 5
Date	25.06.2019
By	Petter Buckholm
Models	K11_07 (ULS/ALS)
	K12_06 (ULS/ALS)
	K13_06 (ULS/ALS)
	K14_07 (ULS/ALS)
	C.S. a,b,c, all wind.dir.
	(results dated 24.06.2019)

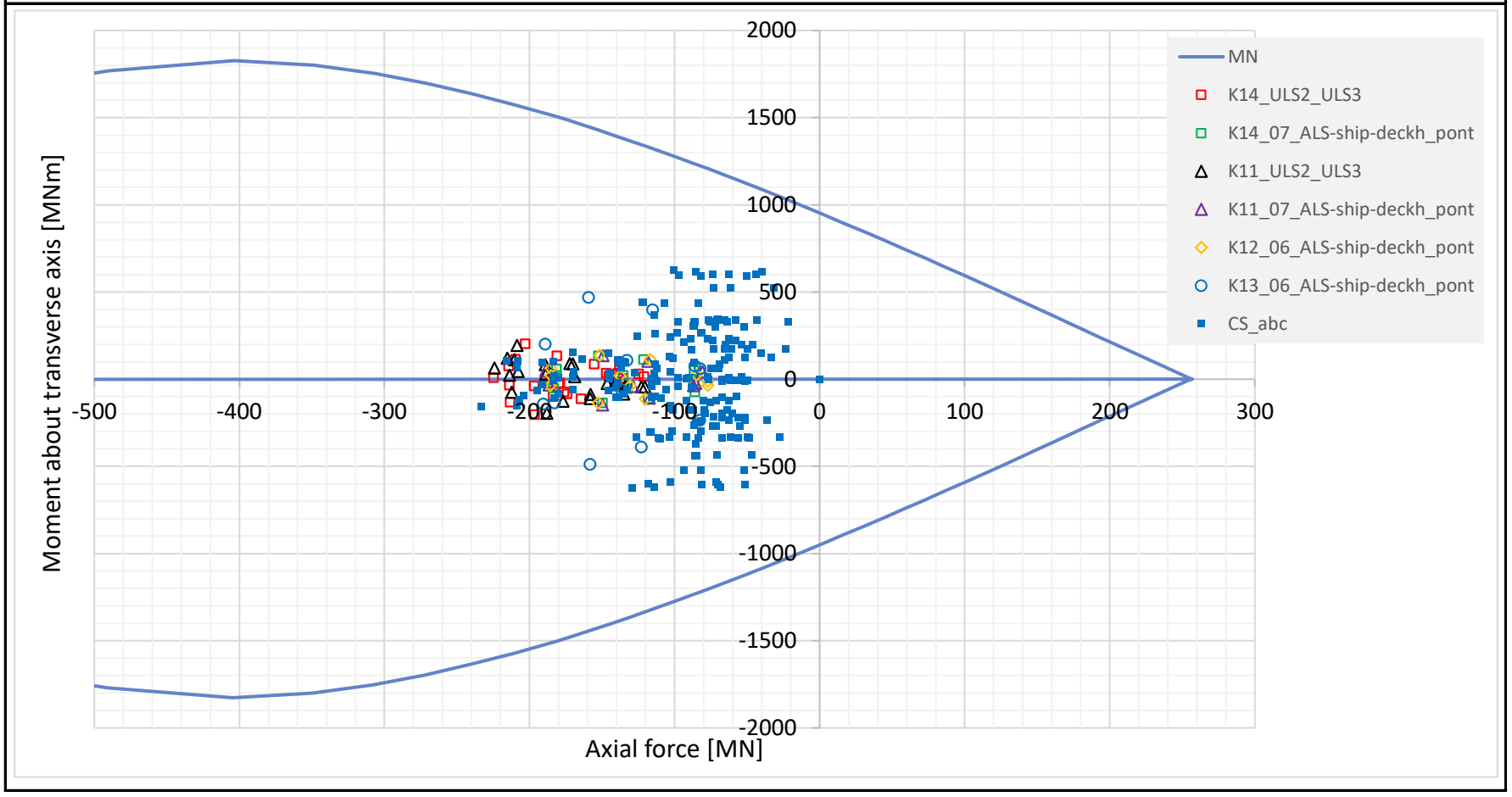




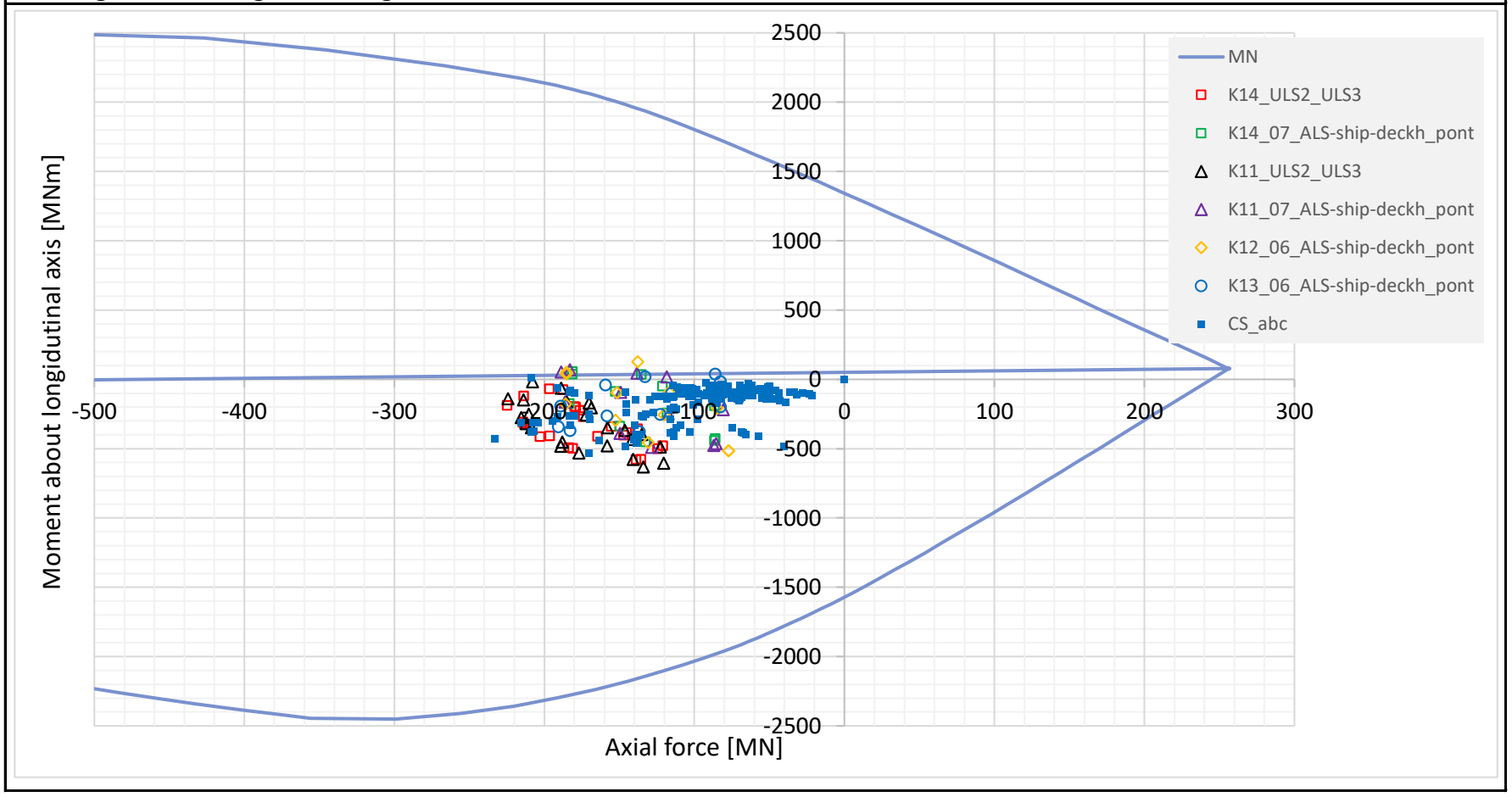
Biaxial bending capacity diagram



MN-diagram - bending about transverse axis



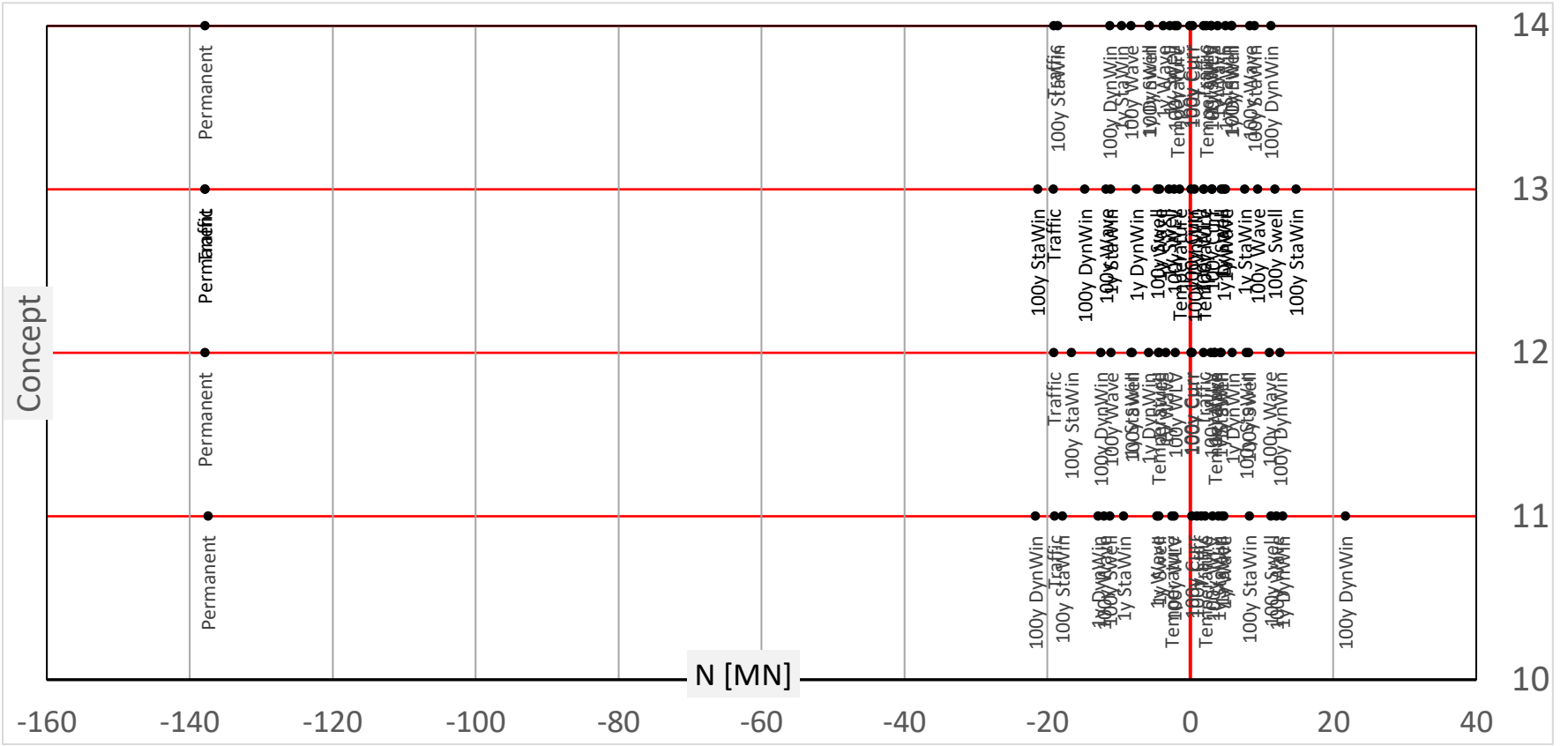
MN-diagram - bending about longitudinal axis

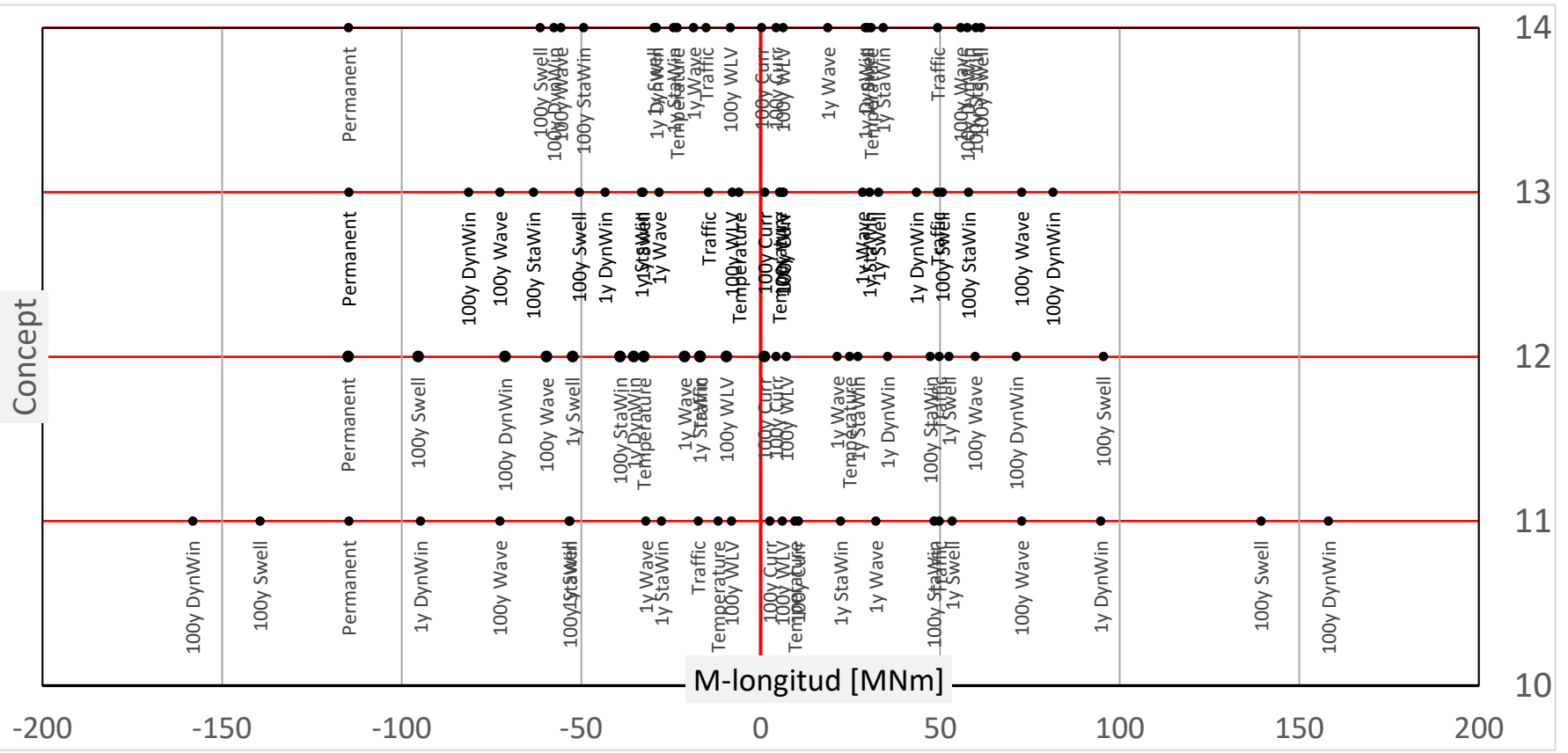


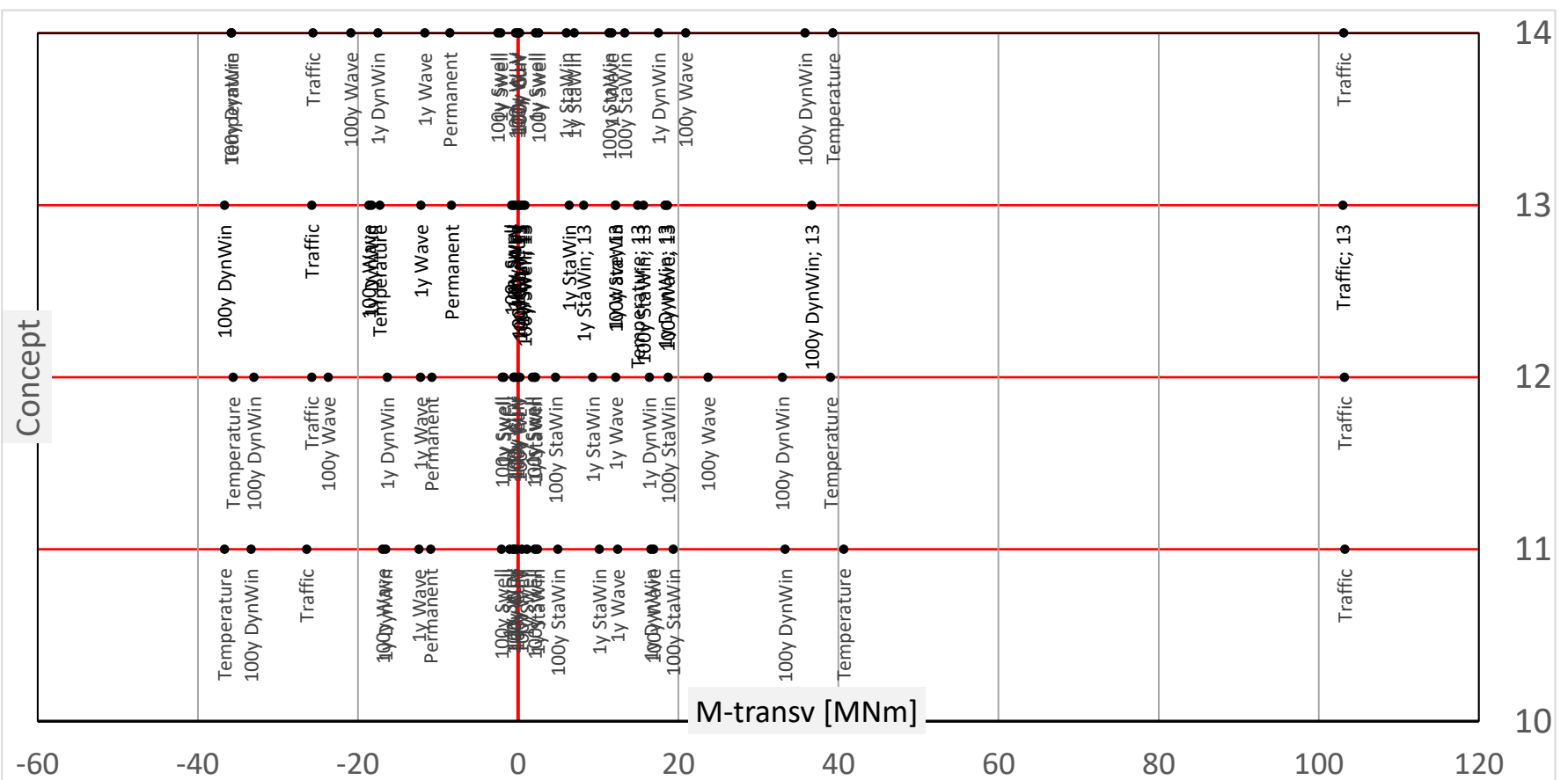
Design loads						
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K14_07	ULS3	Min N	east	-225	8	-188
		Min N	west	-214	-36	-122
		Min M longit	east	-188	-24	-74
		Min M longit	west	-135	2	-578
		Min M transv	east	-176	-75	-225
		Min M transv	west	-138	74	-358
		Max N	east	-125	30	-501
		Max N	west	-121	15	-480
		Max M longit	east	-139	33	-581
		Max M longit	west	-197	-40	-68
		Max M transv	east	-210	114	-327
		Max M transv	west	-164	-114	-412
		_Worst_Min	east	-195	-102	-135
		_Worst_Min	west	-196	101	-488
		_Worst_Max	east	-134	96	-510
		_Worst_Max	west	-135	-95	-132
	ULS2	Min N	east	-214	76	-310
		Min N	west	-213	-133	-323
		Min M longit	east	-179	-23	-203
		Min M longit	west	-184	-99	-494
		Min M transv	east	-174	-86	-269
		Min M transv	west	-155	86	-342
		Max N	east	-147	34	-403
		Max N	west	-145	15	-386
		Max M longit	east	-181	132	-499
		Max M longit	west	-180	-26	-198
		Max M transv	east	-203	202	-413
		Max M transv	west	-196	-204	-409
		_Worst_Min	east	-204	-93	-217
		_Worst_Min	west	-207	93	-470
		_Worst_Max	east	-149	192	-474
		_Worst_Max	west	-150	-193	-215
	ALS-ship-deckh_pont	Min N	east	-183	-52	-176
		Min M longit	east	-132	-56	-453
		Min M transv	east	-150	-138	-339
		Max N	east	-87	48	-192
		Max M longit	east	-135	22	33
		Max M transv	east	-121	112	-50
		Min N	west	-181	57	37
		Min M longit	west	-181	20	56
		Min M transv	west	-153	132	-89
		Max N	west	-86	-75	-429
		Max M longit	west	-86	-12	-442
		Max M transv	west	-118	-111	-244

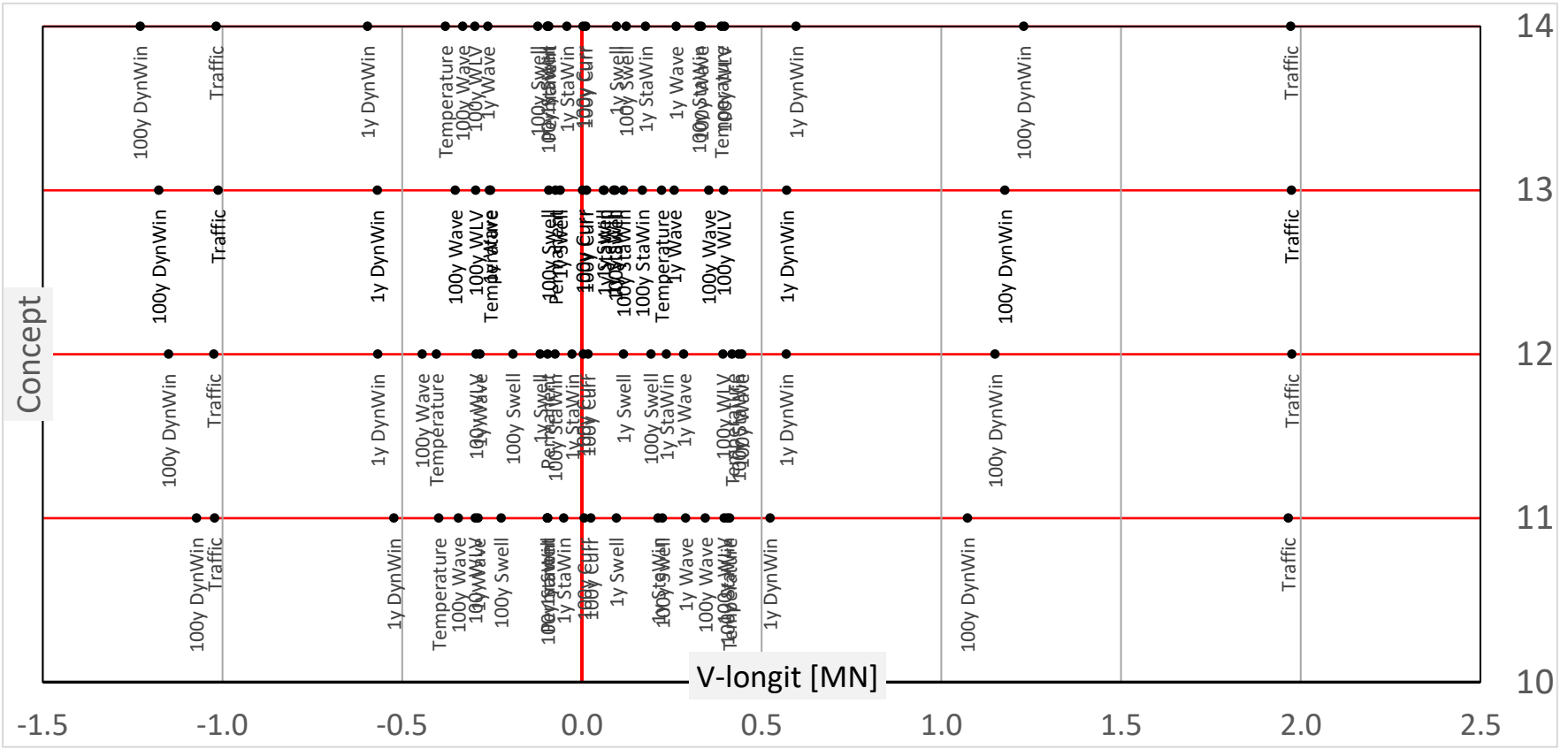
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K12_06	ULS3	Min N	east	-224	63	-141
		Min N	west	-214	23	-148
		Min M longit	east	-208	44	-18
		Min M longit	west	-134	-42	-632
		Min M transv	east	-135	-84	-398
		Min M transv	west	-170	89	-171
		Max N	east	-123	-44	-488
		Max N	west	-120	-44	-606
		Max M longit	east	-141	-32	-578
		Max M longit	west	-189	28	-65
		Max M transv	east	-210	111	-250
		Max M transv	west	-158	-111	-479
		_Worst_Min	east	-199	-97	-75
		_Worst_Min	west	-196	97	-559
		_Worst_Max	east	-131	84	-560
		_Worst_Max	west	-134	-84	-73
	ULS2	Min N	east	-215	119	-275
		Min N	west	-212	-74	-319
		Min M longit	east	-185	24	-160
		Min M longit	west	-177	-126	-532
		Min M transv	east	-158	-87	-348
		Min M transv	west	-172	89	-258
		Max N	east	-146	-25	-369
		Max N	west	-141	-27	-434
		Max M longit	east	-189	84	-483
		Max M longit	west	-169	15	-205
		Max M transv	east	-209	194	-349
		Max M transv	west	-188	-195	-453
		_Worst_Min	east	-207	-92	-180
		_Worst_Min	west	-207	92	-511
		_Worst_Max	east	-147	185	-498
		_Worst_Max	west	-149	-186	-187
K11_07	ALS-ship-deckh_pont	Min N	east	-186	-34	-163
		Min M longit	east	-129	-43	-492
		Min M transv	east	-150	-148	-390
		Max N	east	-81	42	-217
		Max M strong	east	-138	38	46
		Max M weak	east	-119	102	18
		Min N	west	-189	48	52
		Min M longit	west	-183	24	69
		Min M transv	west	-149	135	-94
		Max N	west	-85	-25	-463
		Max M strong	west	-87	-37	-476
		Max M weak	west	-117	-109	-249
K12_06	ALS-ship-deckh_pont	Min N	east	-186	-38	-177
		Min M longit	east	-131	-39	-455
		Min M transv	east	-153	-137	-296
		Max N	east	-85	26	-208
		Max M longit	east	-138	20	128
		Max M transv	east	-117	114	-93
		Min N	west	-185	63	39
		Min M longit	west	-185	21	49
		Min M transv	west	-152	138	-95
		Max N	west	-77	-35	-514
		Max M longit	west	-77	-12	-514
		Max M transv	west	-120	-112	-256
K13_06	ALS-ship-deckh_pont	Min N	east	-191	-144	-345
		Min M longit	east	-183	-137	-371
		Min M transv	east	-158	-490	-265
		Max N	east	-82	60	-18
		Max M longit	east	-86	74	36
		Max M transv	east	-115	396	-101
		Min N	west	-189	200	-194
		Min M longit	west	-133	107	17
		Min M transv	west	-159	468	-41
		Max N	west	-83	-236	-200
		Max M longit	west	-136	-64	-380
		Max M transv	west	-123	-390	-255

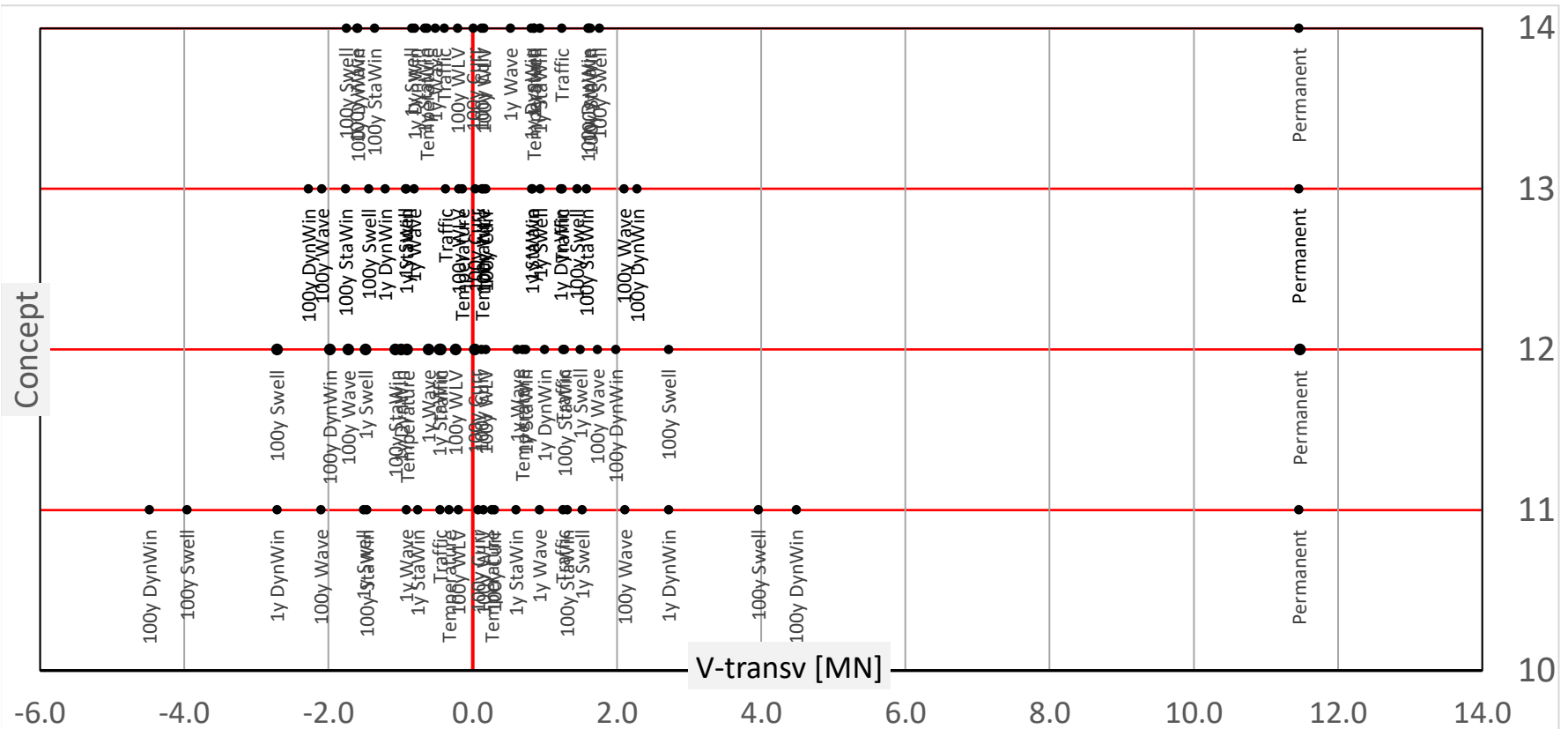
Concept comparson - load actions - Tower leg east (elevation 52)








Concept
V-longit [MN]
14
13
12
11
10
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5


Concept
V-transv [MN]
14
13
12
11
10
-6.0
-4.0
-2.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0

Construction stages - summary

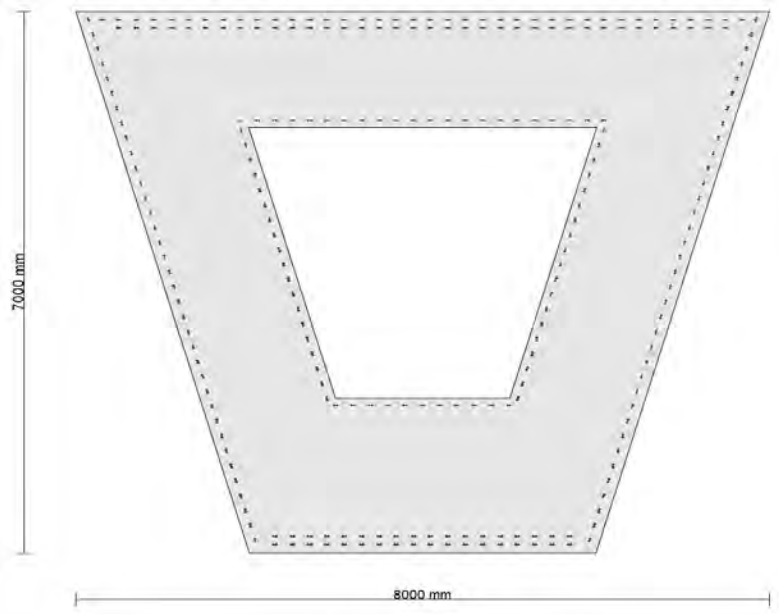
Phase	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
Tower leg west	Phase a	ULS	Max	-24	269	-23
			Min	-103	-604	-126
	Phase b	ULS	Max	-43	369	-44
			Min	-130	-625	-173
	Phase c	ULS	Max	-57	65	11
			Min	-233	-157	-459
Tower leg east	Phase a	ULS	Max	-22	604	-31
			Min	-101	-269	-133
	Phase b	ULS	Max	-40	625	-54
			Min	-126	-369	-182
	Phase c	ULS	Max	-40	156	-60
			Min	-215	-64	-534

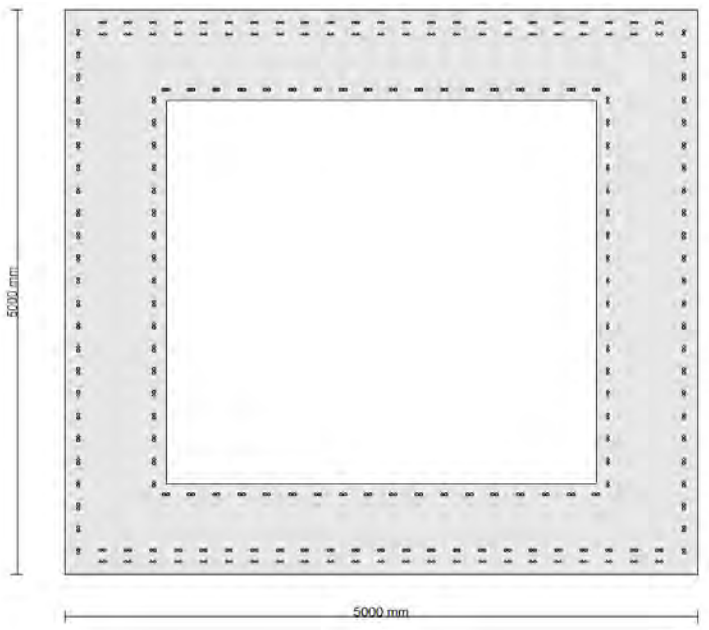
Capacity diagrams

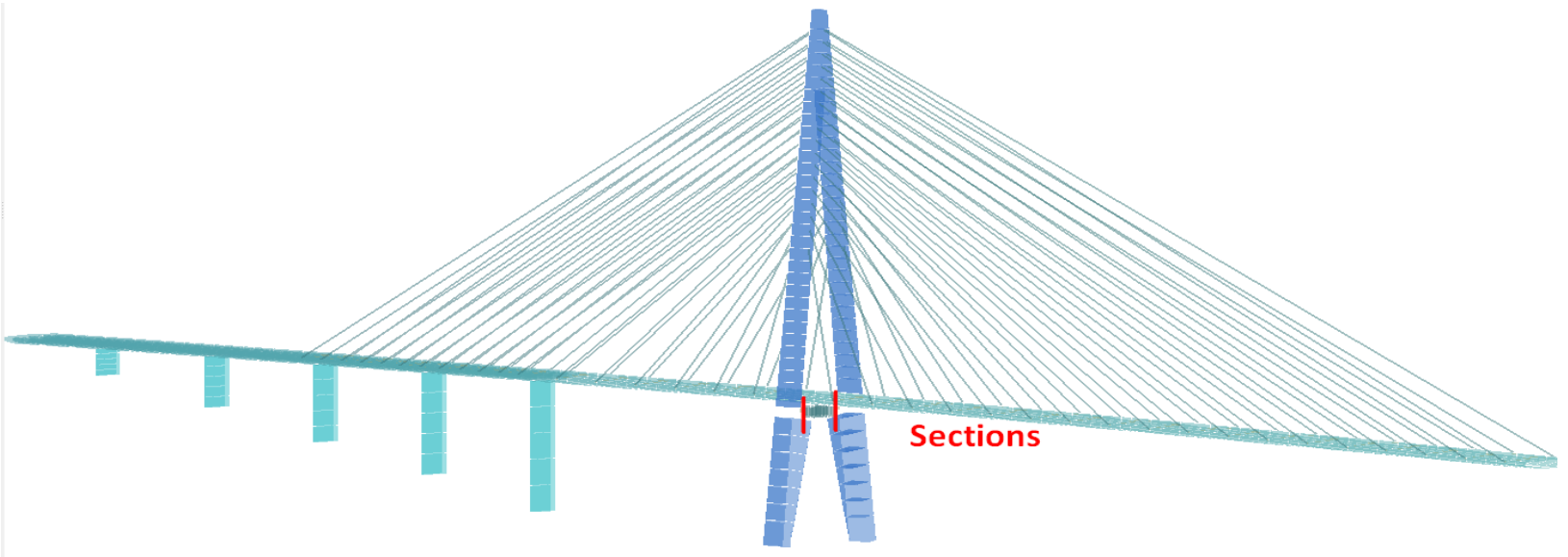
Elevation 0 m

Title	New section		Analyzed 5x5
Ac	3.14E+07	mm2	1.34E+07
Ix	1.55E+14	mm4	4.10E+13
Iy	1.31E+14	mm4	4.10E+13
As	4.07E+05	mm2	341001
rho	1.3 %		2.5 %
	2ø32c200		
	two layers top and bottom		
Elevation	0	m	

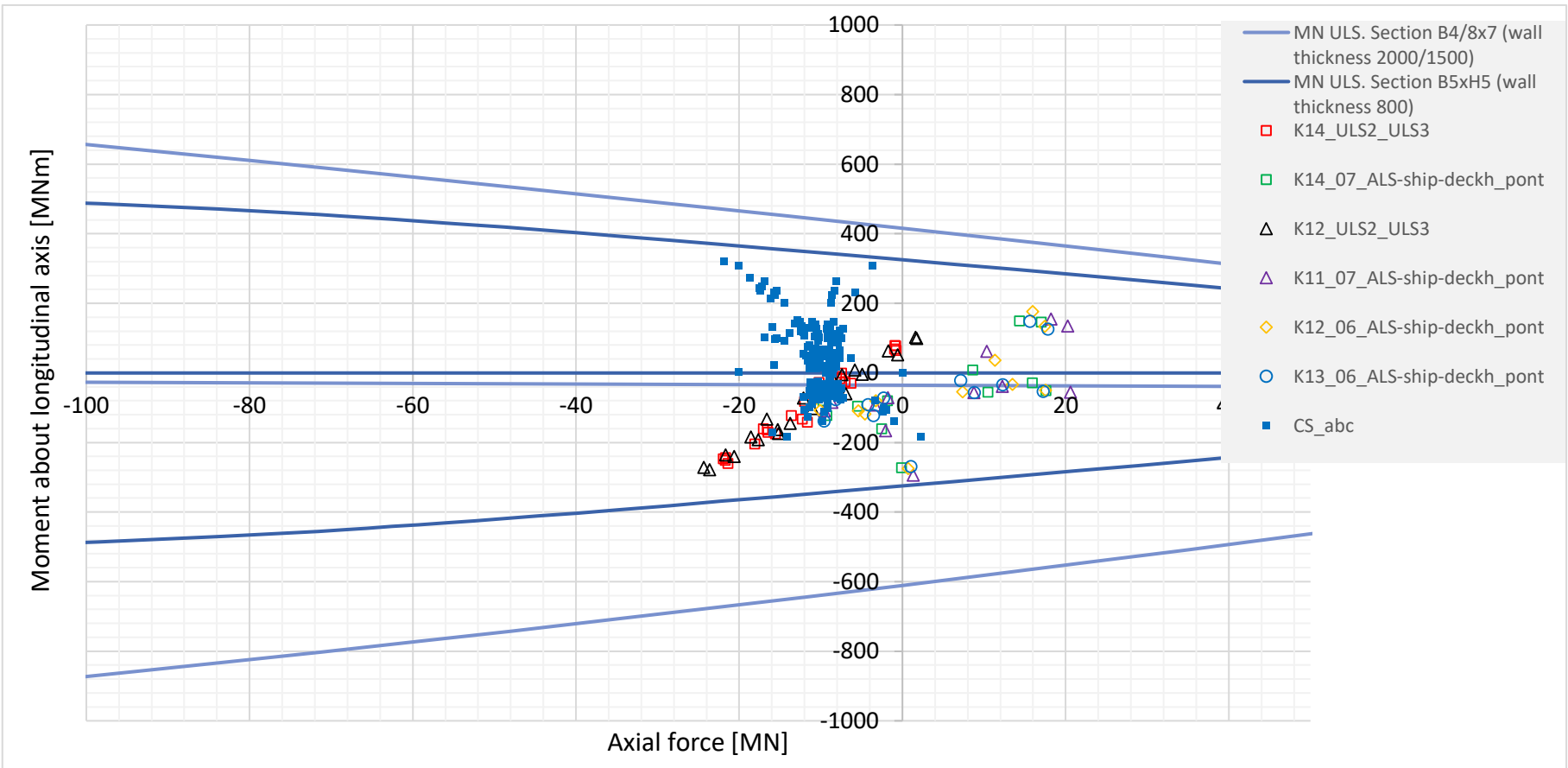
Project	Bjørnafjorden phase 5
Date	25.06.2019
By	Petter Buckholm
Models	K11_07 (ULS/ALS)
	K12_06 (ULS/ALS)
	K13_06 (ULS/ALS)
	K14_07 (ULS/ALS)
	C.S. a,b,c, all wind.dir.
	(results dated 24.06.2019)



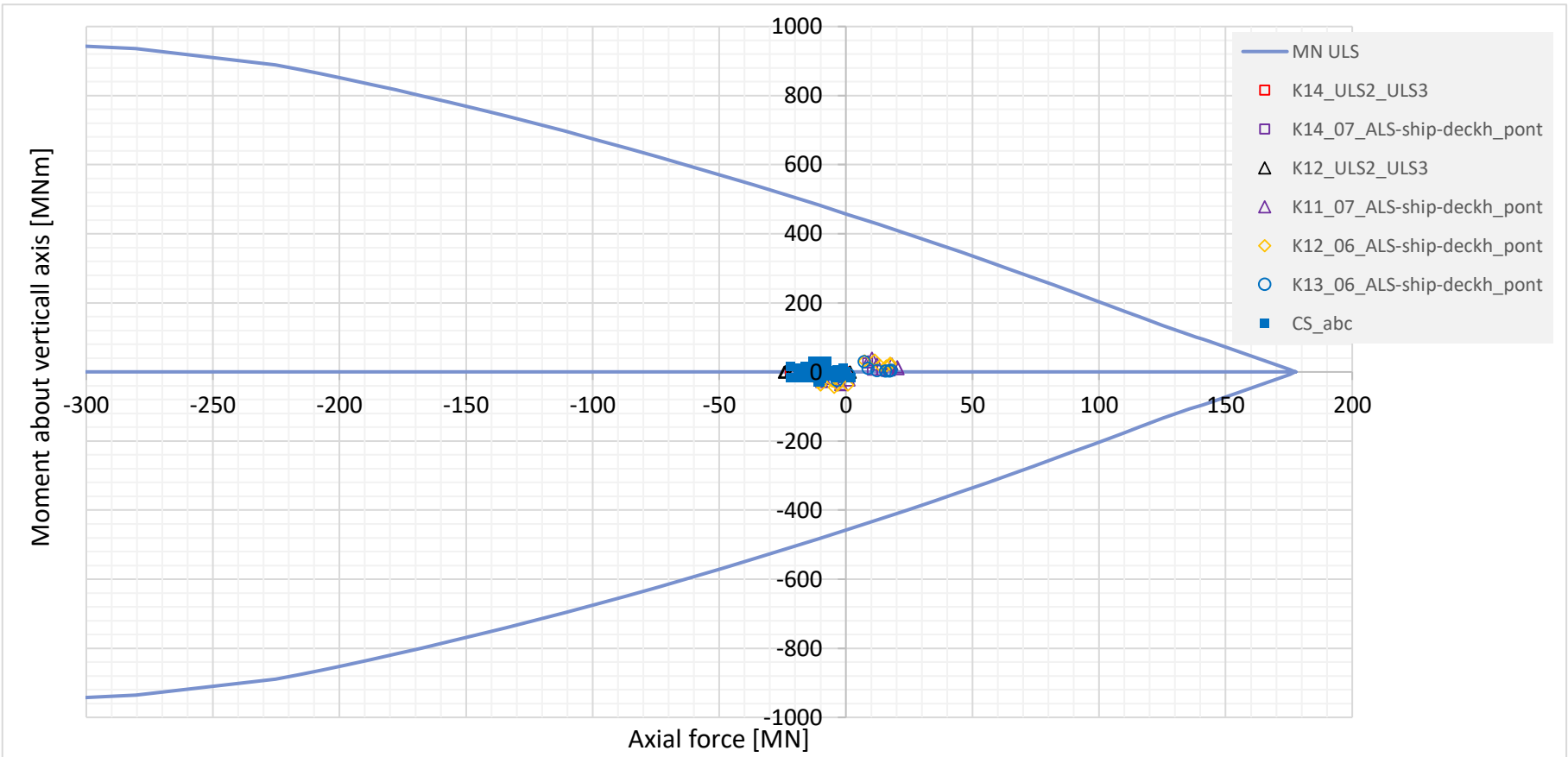




MN-diagram - bending about longitudinal axis



MN-diagram - bending about vertical axis

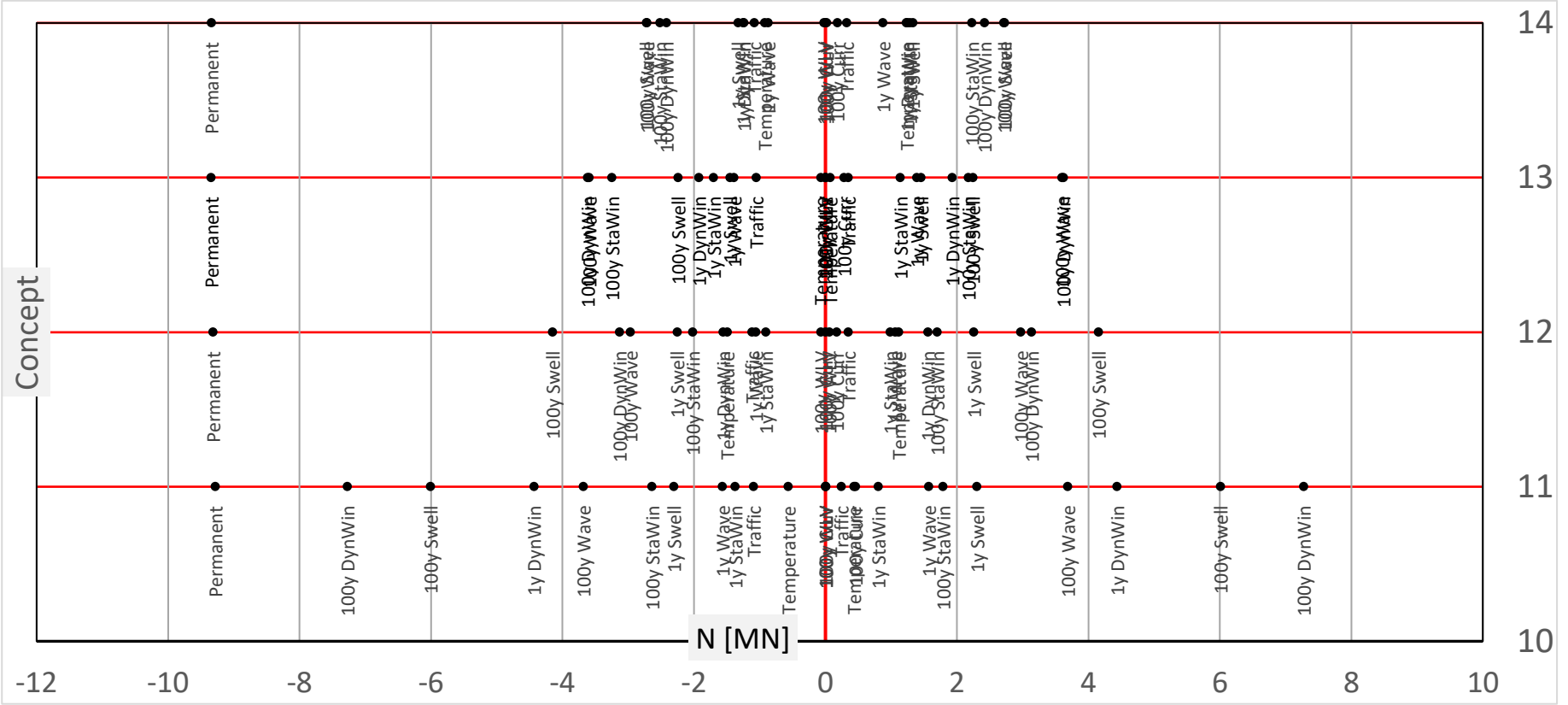


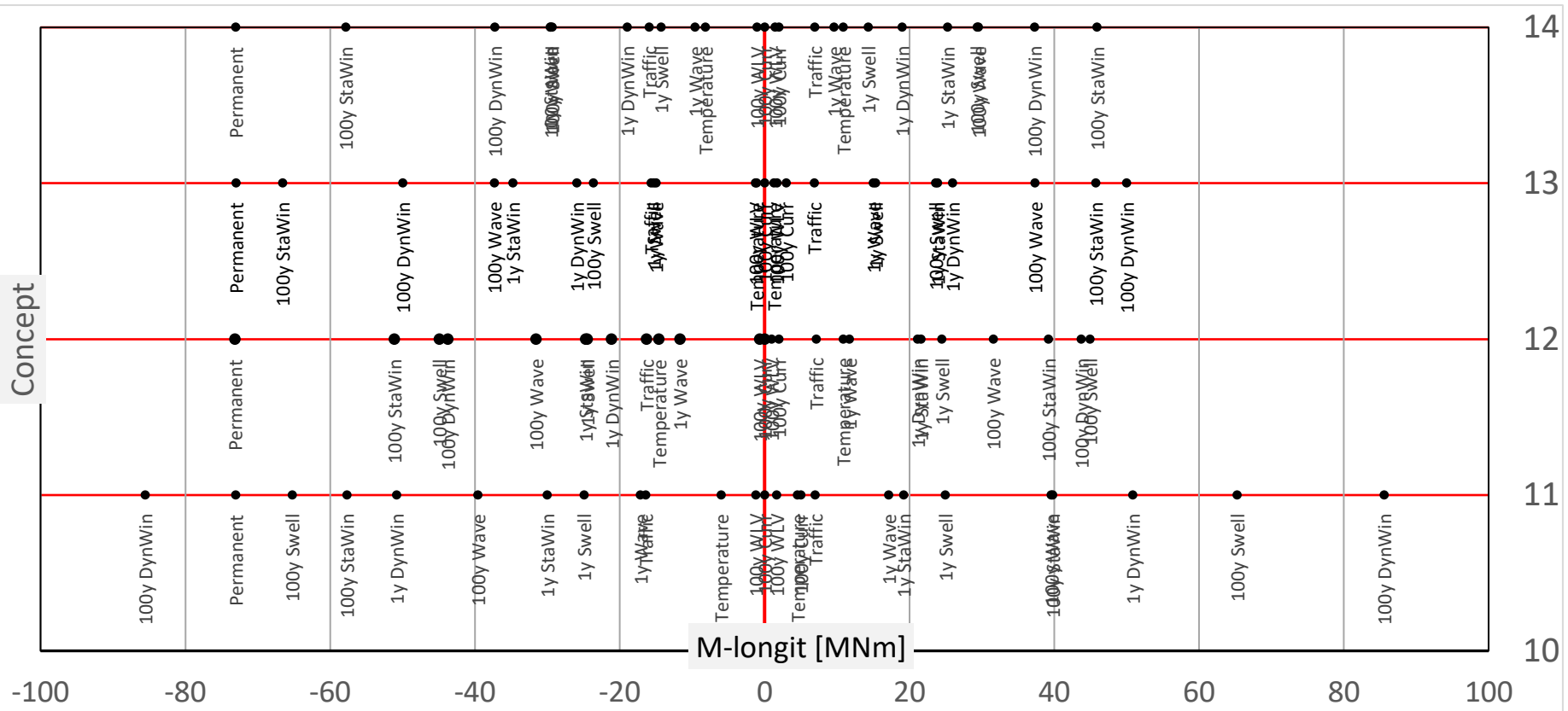
Design loads						
Model	Limit state	Criteria	Criteria2	Axial [MN]	M-longit [MNm]	M-vert [MNm]
K14_07	ULS3	Min N	east	-22	-244	-1
		Min N	west	-22	-247	2
		Min M longit	east	-21	-261	1
		Min M longit	west	-22	-251	2
		Min M vert	east	-18	-204	-3
		Min M vert	west	-7	0	-4
		Max N	east	-1	64	0
		Max N	west	-1	77	-1
		Max M longit	east	-1	69	-1
		Max M longit	west	-1	78	-1
		Max M vert	east	-12	-142	3
		Max M vert	west	-10	-27	3
		_Worst_Min	east	-18	-177	-3
		_Worst_Min	west	-19	-184	-3
		_Worst_Max	east	-3	8	3
		_Worst_Max	west	-4	4	3
	ULS2	Min N	east	-17	-164	0
		Min N	west	-17	-161	1
		Min M longit	east	-16	-176	1
		Min M longit	west	-16	-170	1
		Min M vert	east	-14	-122	-3
		Min M vert	west	-10	-46	-3
		Max N	east	-6	-29	0
		Max N	west	-7	-26	-1
		Max M longit	east	-8	-16	-1
		Max M longit	west	-8	-10	-1
		Max M vert	east	-12	-133	3
		Max M vert	west	-12	-82	3
		_Worst_Min	east	-16	-146	-3
		_Worst_Min	west	-16	-148	-3
		_Worst_Max	east	-7	-37	3
		_Worst_Max	west	-8	-37	3
	ALS-ship-deckh_pont	Min N	east	-9	-123	-6
		Min M longit	east	0	-273	-2
		Min M transv	east	-3	-161	-29
		Max N	east	17	146	4
		Max M longit	east	14	149	5
		Max M transv	east	9	8	27
		Min N	west	-10	-80	-2
		Min M longit	west	-5	-96	-2
		Min M transv	west	-2	-80	-4
		Max N	west	18	-51	2
		Max M longit	west	16	-28	2
		Max M transv	west	10	-55	5

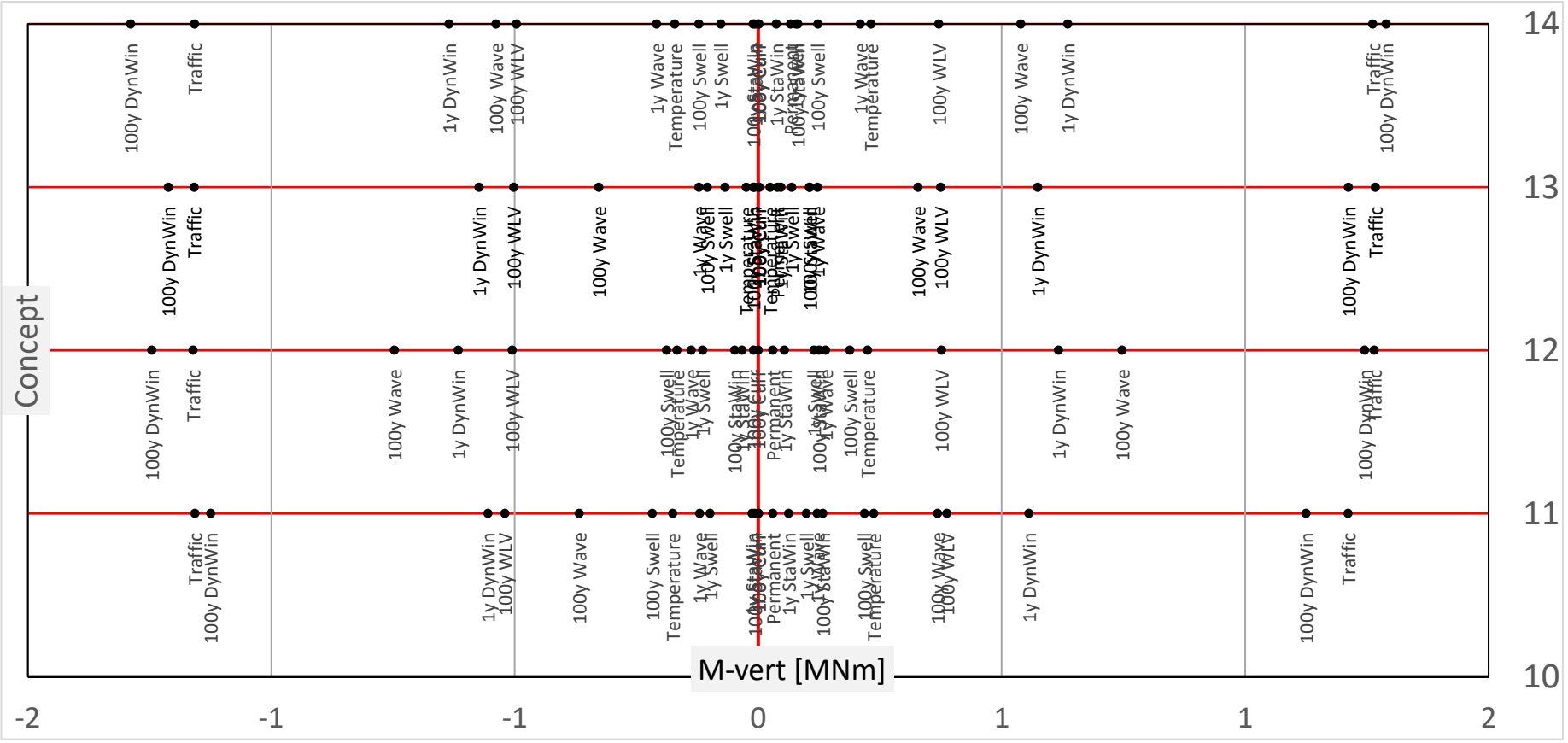
Model	Limit state	Criteria	Criteria2	Axial [MN]	M-longit [MNm]	M-vert [MNm]
K12_06	ULS3	Min N	east	-24	-271	0
		Min N	west	-22	-235	1
		Min M longit	east	-24	-278	1
		Min M longit	west	-21	-240	1
		Min M vert	east	-7	-5	-3
		Min M vert	west	-10	-39	-3
		Max N	east	-1	52	-1
		Max N	west	2	99	-1
		Max M longit	east	-2	63	-1
		Max M longit	west	2	102	0
		Max M vert	east	-15	-174	3
		Max M vert	west	-10	-44	3
		_Worst_Min	east	-22	-208	-3
		_Worst_Min	west	-22	-209	-3
		_Worst_Max	east	-1	33	3
		_Worst_Max	west	-1	33	3
	ULS2	Min N	east	-19	-184	0
		Min N	west	-17	-132	1
		Min M longit	east	-18	-192	1
		Min M longit	west	-15	-163	1
		Min M vert	east	-11	-103	-3
		Min M vert	west	-12	-72	-3
		Max N	east	-7	-60	0
		Max N	west	-5	-4	-1
		Max M longit	east	-8	-24	-1
		Max M longit	west	-6	8	-1
		Max M vert	east	-14	-145	3
		Max M vert	west	-10	-65	3
		_Worst_Min	east	-17	-162	-3
		_Worst_Min	west	-17	-158	-3
		_Worst_Max	east	-6	-26	3
		_Worst_Max	west	-6	-21	3
	ALS-ship-deckh_pont	Min N	east	-10	-108	-38
		Min M longit	east	1	-275	-38
		Min M transv	east	-5	-118	-45
		Max N	east	17	134	21
		Max M longit	east	16	176	17
		Max M transv	east	11	37	34
		Min N	west	-11	-75	-29
		Min M longit	west	-5	-109	-27
		Min M transv	west	-3	-80	-38
		Max N	west	18	-49	25
		Max M longit	west	13	-33	18
		Max M transv	west	7	-54	32

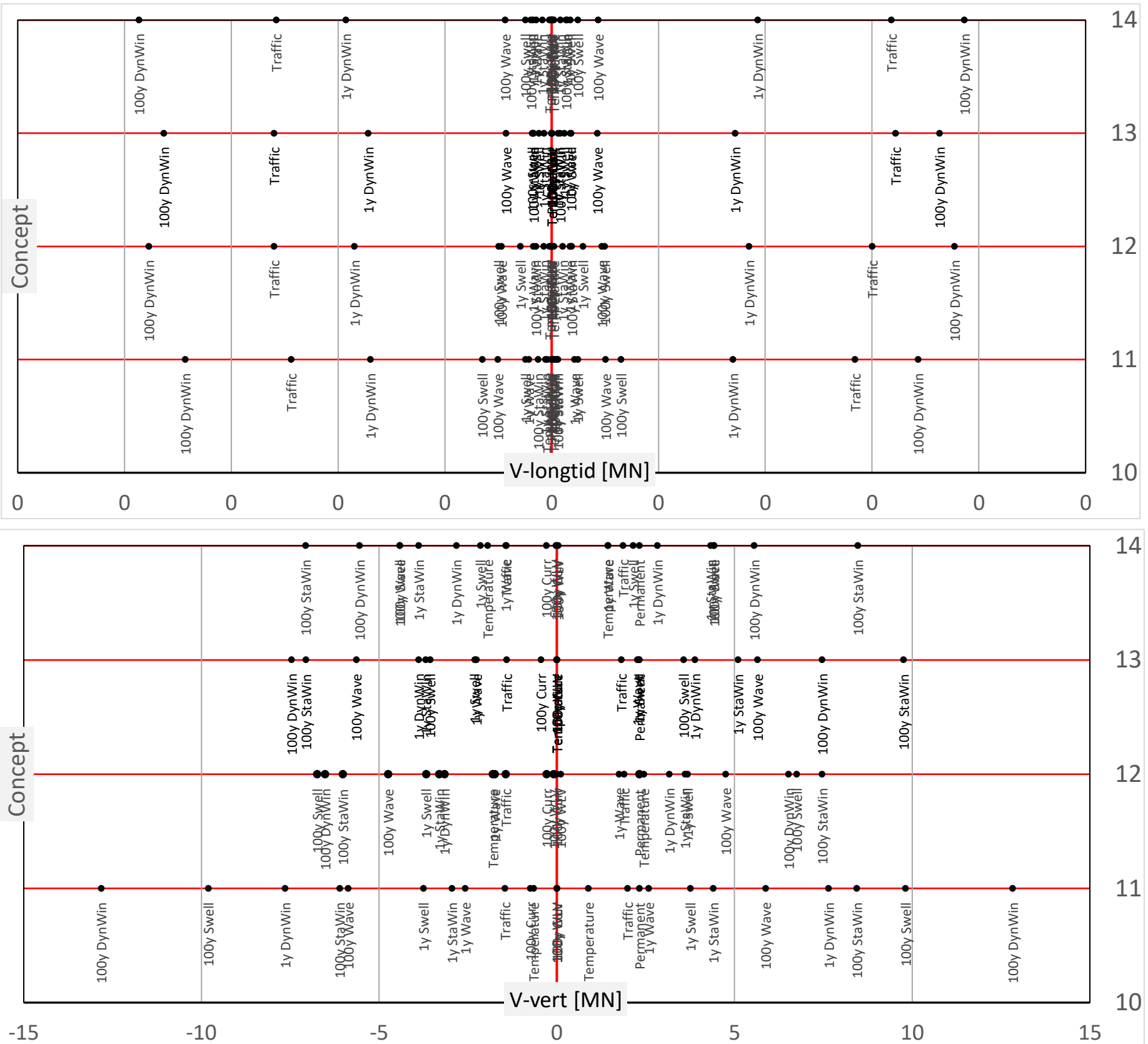
Model	Limit state	Criteria	Criteria2	Axial [MN]	M-longit [MNm]	M-vert [MNm]
K11_07	ALS-ship-deckh_pont	Min N	east	-10	-110	-27
		Min M longit	east	1	-293	-23
		Min M transv	east	-2	-167	-37
		Max N	east	20	135	15
		Max M strong	east	18	154	23
		Max M weak	east	10	62	40
		Min N	west	-9	-84	-19
		Min M longit	west	-3	-93	-19
		Min M transv	west	-2	-72	-35
		Max N	west	21	-55	9
		Max M strong	west	12	-39	23
		Max M weak	west	9	-56	30
K13_06	ALS-ship-deckh_pont	Min N	east	-10	-138	-12
		Min M longit	east	1	-269	-7
		Min M transv	east	-4	-123	-24
		Max N	east	18	126	4
		Max M longit	east	16	149	3
		Max M transv	east	7	-22	29
		Min N	west	-8	-76	-6
		Min M longit	west	-4	-91	-10
		Min M transv	west	-2	-72	-13
		Max N	west	17	-53	3
		Max M longit	west	12	-35	4
		Max M transv	west	9	-56	10

Concept comparson - load actions -Tower cross beam @ east








Concept
V-longtid [MN]
V-vert [MN]
14
13
12
11
10
-15
-10
-5
0
5
10
15

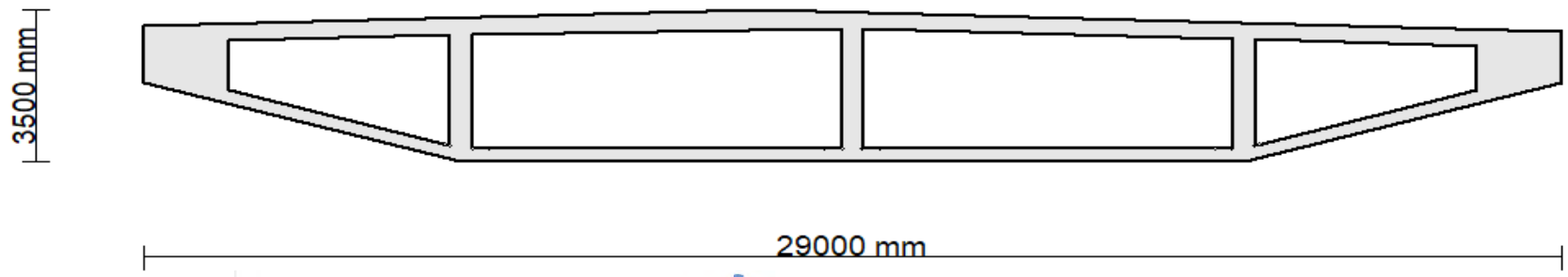
Construction stages - summary

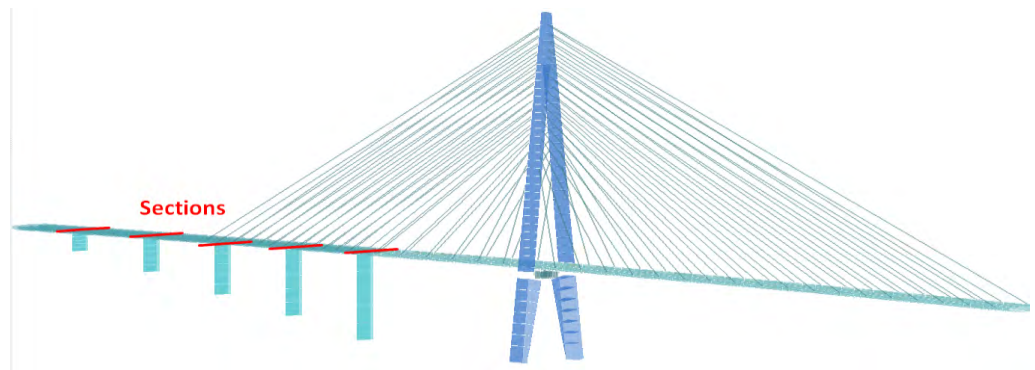
Detail	Phase	LS	Criteria2	Axial [MN]	M longit [MNm]	M vert [MNm]
Tower cross beam west end	Phase a	ULS	Max	-7	133	4
			Min	-11	-67	-4
	Phase b	ULS	Max	-8	152	31
			Min	-13	-71	-28
	Phase c	ULS	Max	-1	320	16
			Min	-22	-139	-17
Tower cross beam east end	Phase a	ULS	Max	-7	128	4
			Min	-11	-71	-4
	Phase b	ULS	Max	-8	147	31
			Min	-13	-77	-29
	Phase c	ULS	Max	2	275	16
			Min	-19	-183	-16

Capacity diagrams

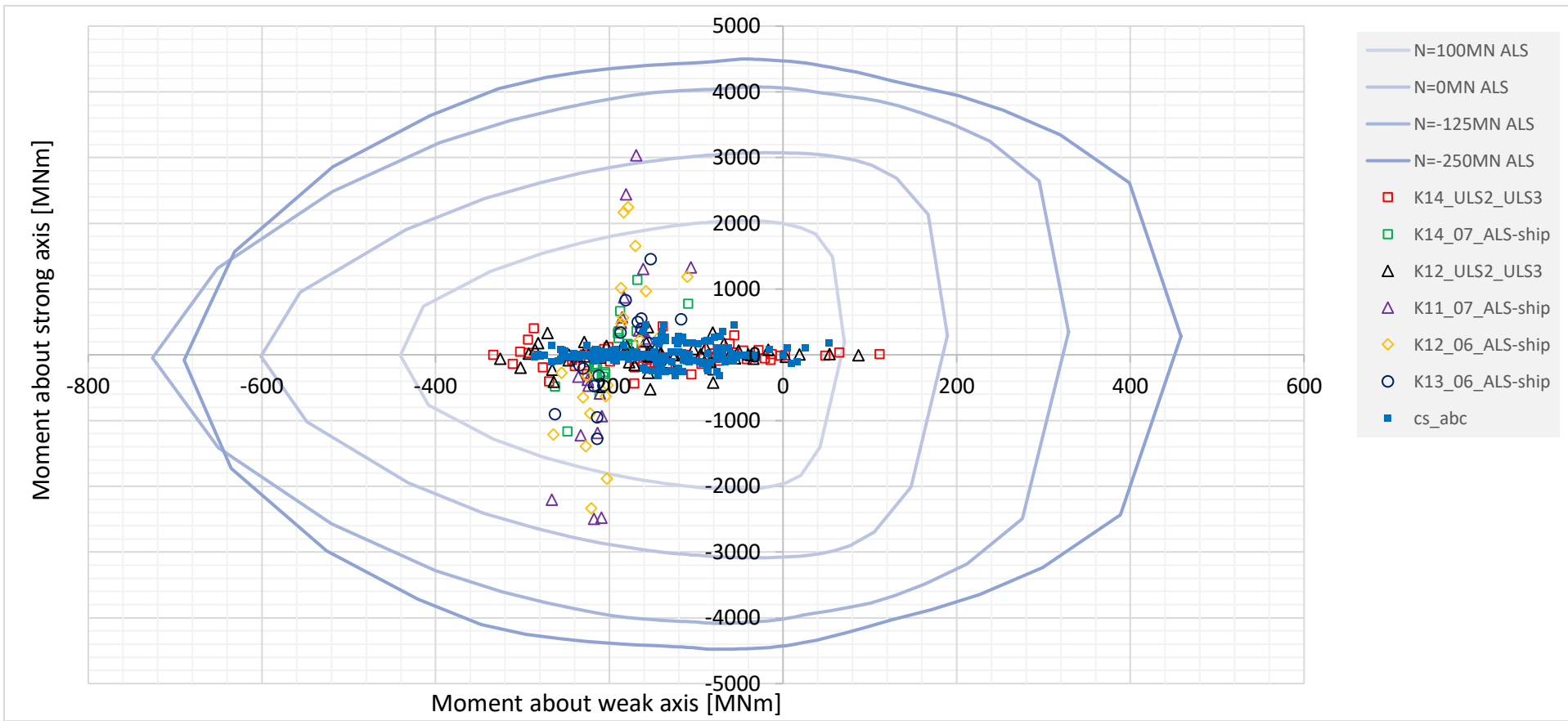
Title	Concrete back span - support sections	
Ac	2.70E+07	mm2
Ix	3.87E+13	mm4
Iy	2.10E+15	mm4
As	3.25E+05	mm2
rho-s	1.20 %	
	ø20c150 top/bottom top/botom flange	
	replaced by ø32c150 outer 6.5m part top flange	
	20ø32 left/right edge	
Ap	6.84E+04	mm2
rho-p	0.25 %	
	6*4*2850mm2	

Project	Bjørnafjorden phase 5
Date	25.06.2019
By	Petter Buckholm
Models	K11_07 (ULS/ALS)
	K12_06 (ULS/ALS)
	K13_06 (ULS/ALS)
	K14_07 (ULS/ALS)
	C.S. a,b,c, all wind.dir.
	(results dated 24.06.2019)

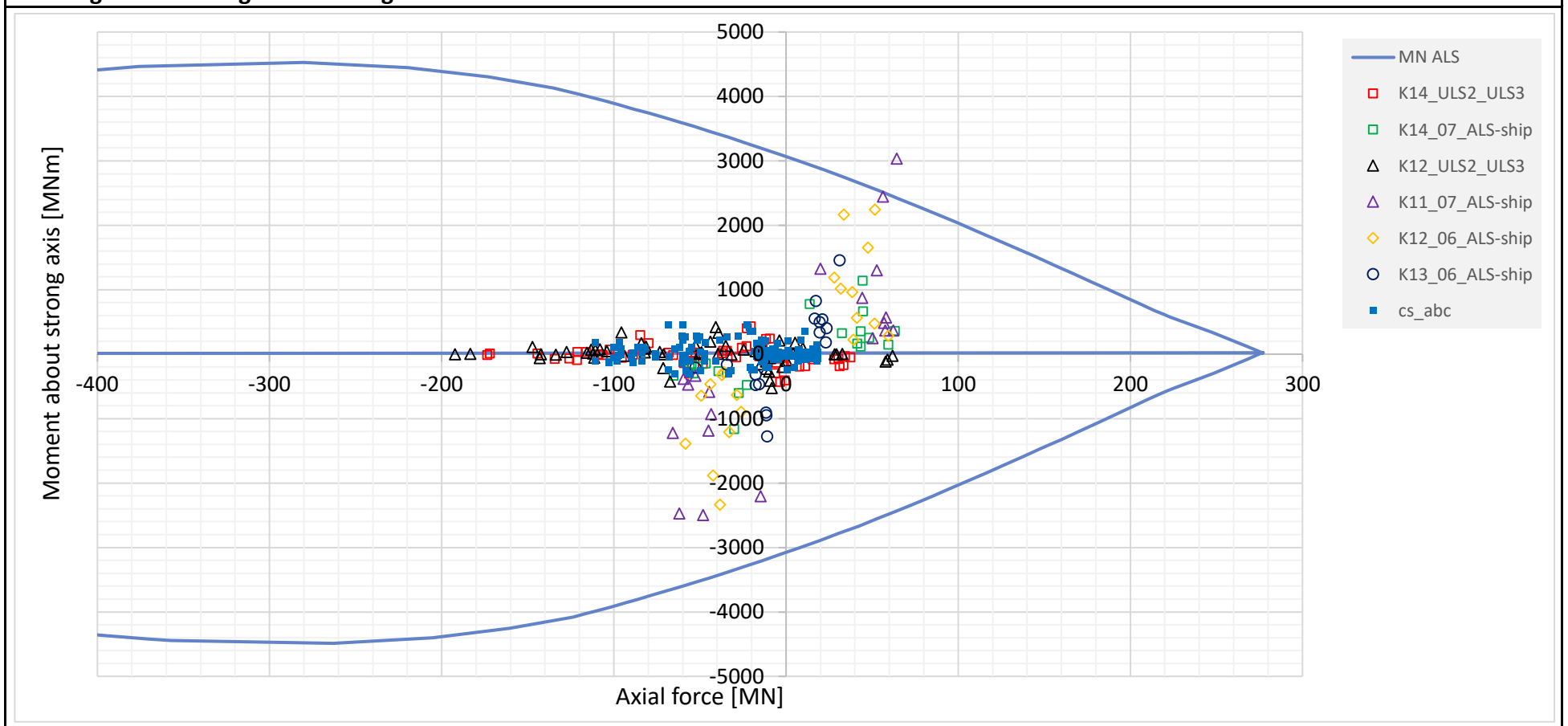




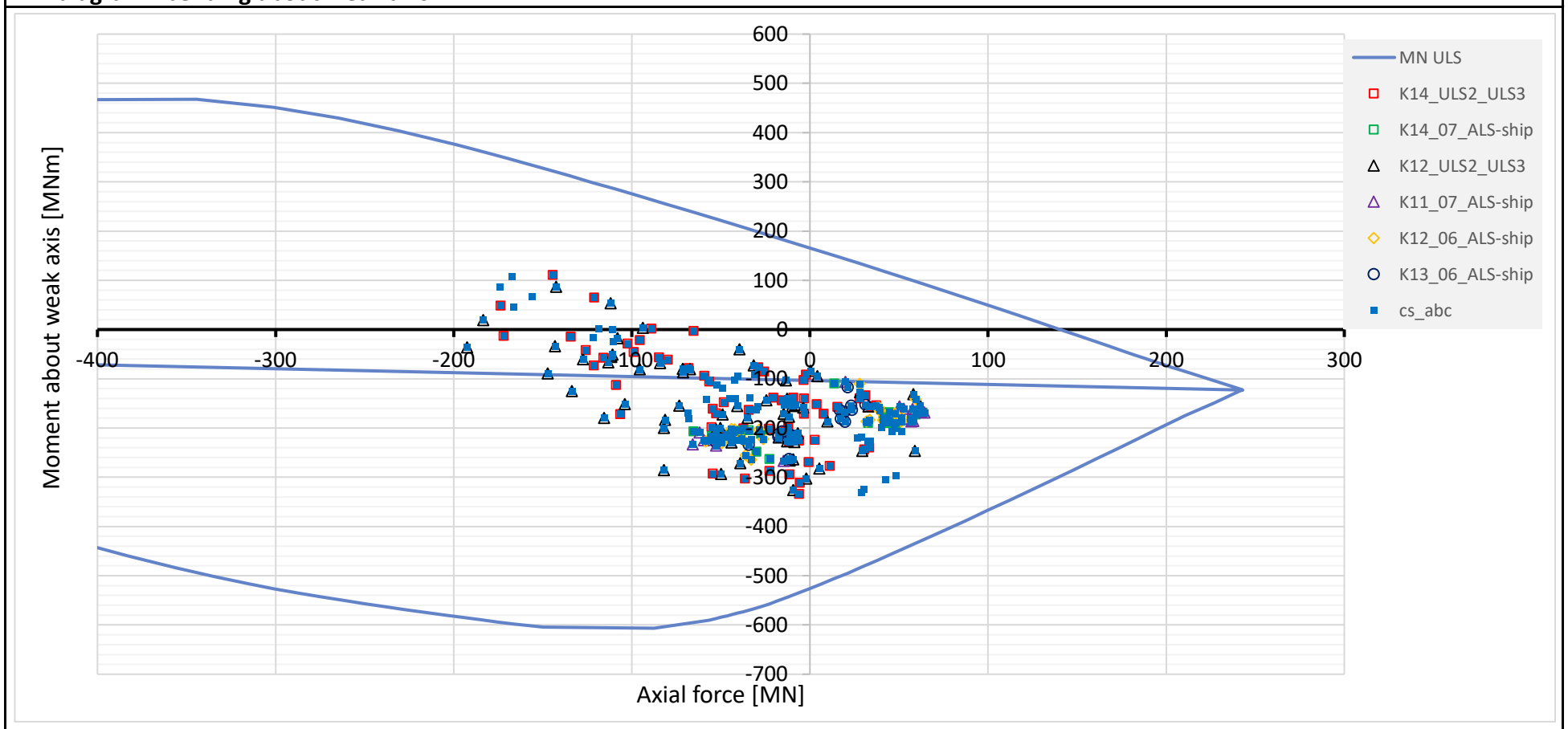
Biaxial bending capacity diagram



MN-diagram - bending about strong axis



MN-diagram - bending about weak axis



Design loads

Model	Limit state	Criteria	Profile	Axial [MN]	M-strong [MNm]	M-weak [MNm]
K14_07	ULS3	Min N	38570	-55	12	-198
		Min N	38625	-55	28	-293
		Min N	38680	-53	23	-170
		Min N	38735	-121	-89	-73
		Min N	38790	-172	12	-13
		Min M strong	38570	4	-119	-152
		Min M strong	38625	-1	-406	-269
		Min M strong	38680	-3	-433	-171
		Min M strong	38735	-56	-299	-106
		Min M strong	38790	-134	-74	-14
		Min M weak	38570	-16	-12	-144
		Min M weak	38625	-6	-291	-226
		Min M weak	38680	-4	-64	-102
		Min M weak	38735	-95	-53	-21
		Min M weak	38790	-121	36	65
		Max N	38570	37	-51	-154
		Max N	38625	33	-171	-240
		Max N	38680	31	-187	-134
		Max N	38735	-26	99	-85
		Max N	38790	-65	-14	-3
		Max M strong	38570	-23	121	-201
		Max M strong	38625	-23	405	-287
		Max M strong	38680	-21	431	-139
		Max M strong	38735	-85	296	-56
		Max M strong	38790	-102	72	-28
		Max M weak	38570	-16	-33	-209
		Max M weak	38625	-6	-135	-311
		Max M weak	38680	-12	-101	-199
		Max M weak	38735	-48	-147	-147
		Max M weak	38790	-109	0	-112
	ULS2	Min N	38570	-37	16	-200
		Min N	38625	-36	50	-303
		Min N	38680	-34	51	-163
		Min N	38735	-116	33	-57
		Min N	38790	-174	-12	48
		Min M strong	38570	15	-80	-157
		Min M strong	38625	11	-188	-277
		Min M strong	38680	8	-190	-171
		Min M strong	38735	-59	-137	-94
		Min M strong	38790	-126	-66	-42
		Min M weak	38570	-3	-33	-140
		Min M weak	38625	3	-111	-224
		Min M weak	38680	-2	-56	-91
		Min M weak	38735	-89	-9	2
		Min M weak	38790	-144	13	111
		Max N	38570	34	-28	-156
		Max N	38625	30	-76	-243
		Max N	38680	28	-77	-140
		Max N	38735	-29	-48	-77
		Max N	38790	-68	23	-78
		Max M strong	38570	-14	90	-206
		Max M strong	38625	-12	234	-294
		Max M strong	38680	-9	241	-138
		Max M strong	38735	-80	174	-61
		Max M strong	38790	-99	67	-46
		Max M weak	38570	-12	7	-228
		Max M weak	38625	-6	-2	-334
		Max M weak	38680	-7	-7	-219
		Max M weak	38735	-55	-44	-161
		Max M weak	38790	-107	-14	-171

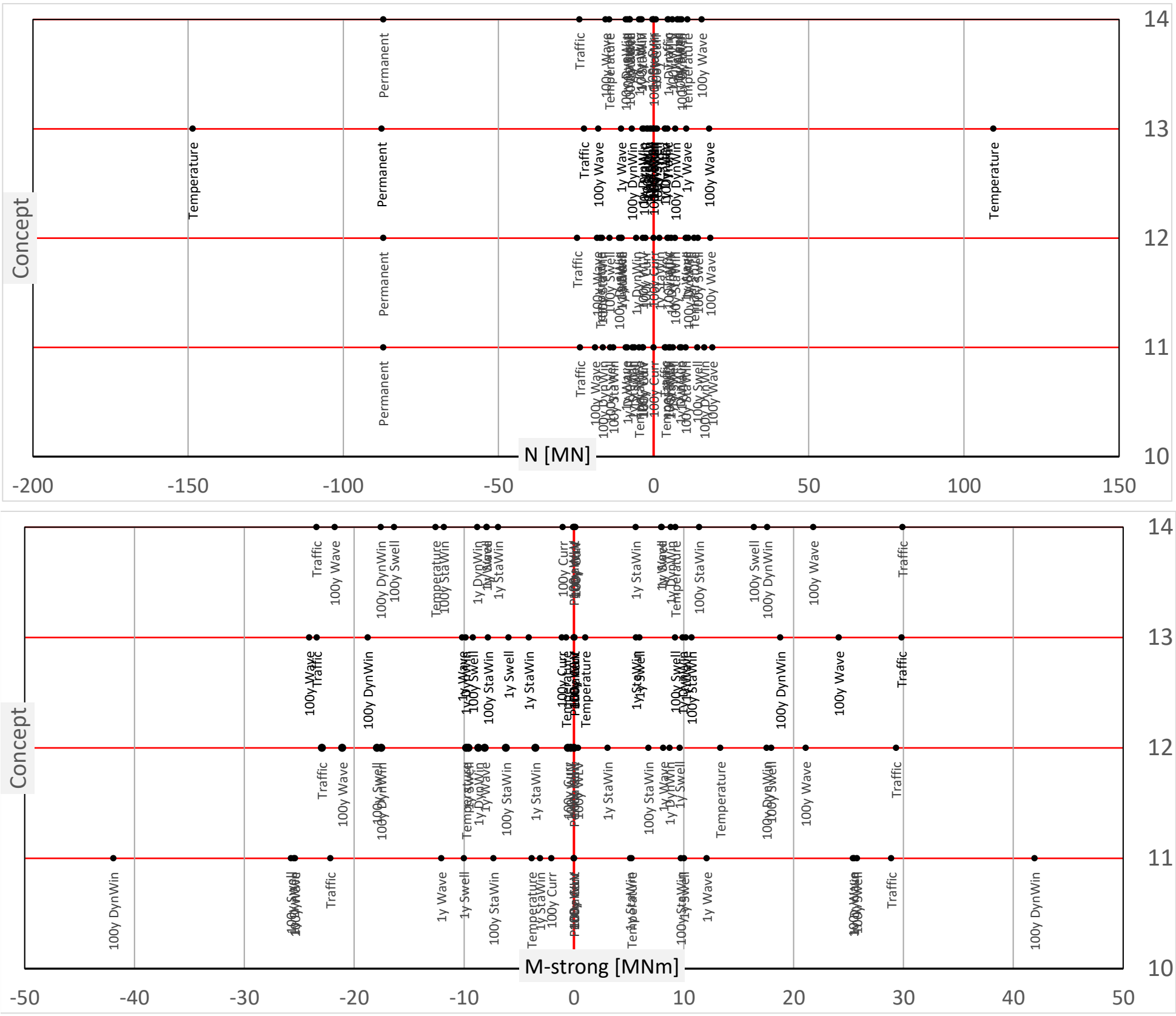
Model	Limit state	Criteria	Profile	Axial [MN]	M-strong [MNm]	M-weak [MNm]
K12_06	ULS3	Min N	38570	-82	27	-200
		Min N	38625	-82	85	-286
		Min N	38680	-81	120	-184
		Min N	38735	-147	115	-89
		Min N	38790	-192	-4	-36
		Min M strong	38570	-15	-155	-171
		Min M strong	38625	-9	-409	-264
		Min M strong	38680	-8	-525	-153
		Min M strong	38735	-67	-424	-80
		Min M strong	38790	-143	-61	-34
		Min M weak	38570	-25	72	-144
		Min M weak	38625	-44	193	-229
		Min M weak	38680	-13	86	-103
		Min M weak	38735	-108	77	-17
		Min M weak	38790	-112	9	54
		Max N	38570	62	-26	-154
		Max N	38625	59	-82	-247
		Max N	38680	58	-112	-131
		Max N	38735	0	-105	-84
		Max N	38790	-39	5	-40
		Max M strong	38570	-35	130	-180
		Max M strong	38625	-39	333	-271
		Max M strong	38680	-41	422	-156
		Max M strong	38735	-96	339	-81
		Max M strong	38790	-111	65	-51
		Max M weak	38570	-7	-41	-211
		Max M weak	38625	-2	-199	-302
		Max M weak	38680	-53	134	-203
		Max M weak	38735	-104	44	-151
		Max M weak	38790	-134	-7	-125
	ULS2	Min N	38570	-50	2	-200
		Min N	38625	-50	18	-293
		Min N	38680	-49	29	-173
		Min N	38735	-127	33	-60
		Min N	38790	-183	5	19
		Min M strong	38570	-12	-115	-177
		Min M strong	38625	-11	-225	-266
		Min M strong	38680	-10	-271	-155
		Min M strong	38735	-71	-217	-80
		Min M strong	38790	-111	-56	-55
		Min M weak	38570	-13	33	-141
		Min M weak	38625	-13	77	-227
		Min M weak	38680	4	12	-95
		Min M weak	38735	-94	-27	3
		Min M weak	38790	-142	-3	87
		Max N	38570	33	2	-156
		Max N	38625	29	-1	-247
		Max N	38680	28	-3	-127
		Max N	38735	-32	-7	-73
		Max N	38790	-71	-4	-87
		Max M strong	38570	10	91	-186
		Max M strong	38625	5	180	-282
		Max M strong	38680	-4	212	-158
		Max M strong	38735	-84	174	-68
		Max M strong	38790	-113	72	-67
		Max M weak	38570	-9	-25	-229
		Max M weak	38625	-9	-60	-326
		Max M weak	38680	-18	47	-219
		Max M weak	38735	-73	34	-155
		Max M weak	38790	-116	23	-180

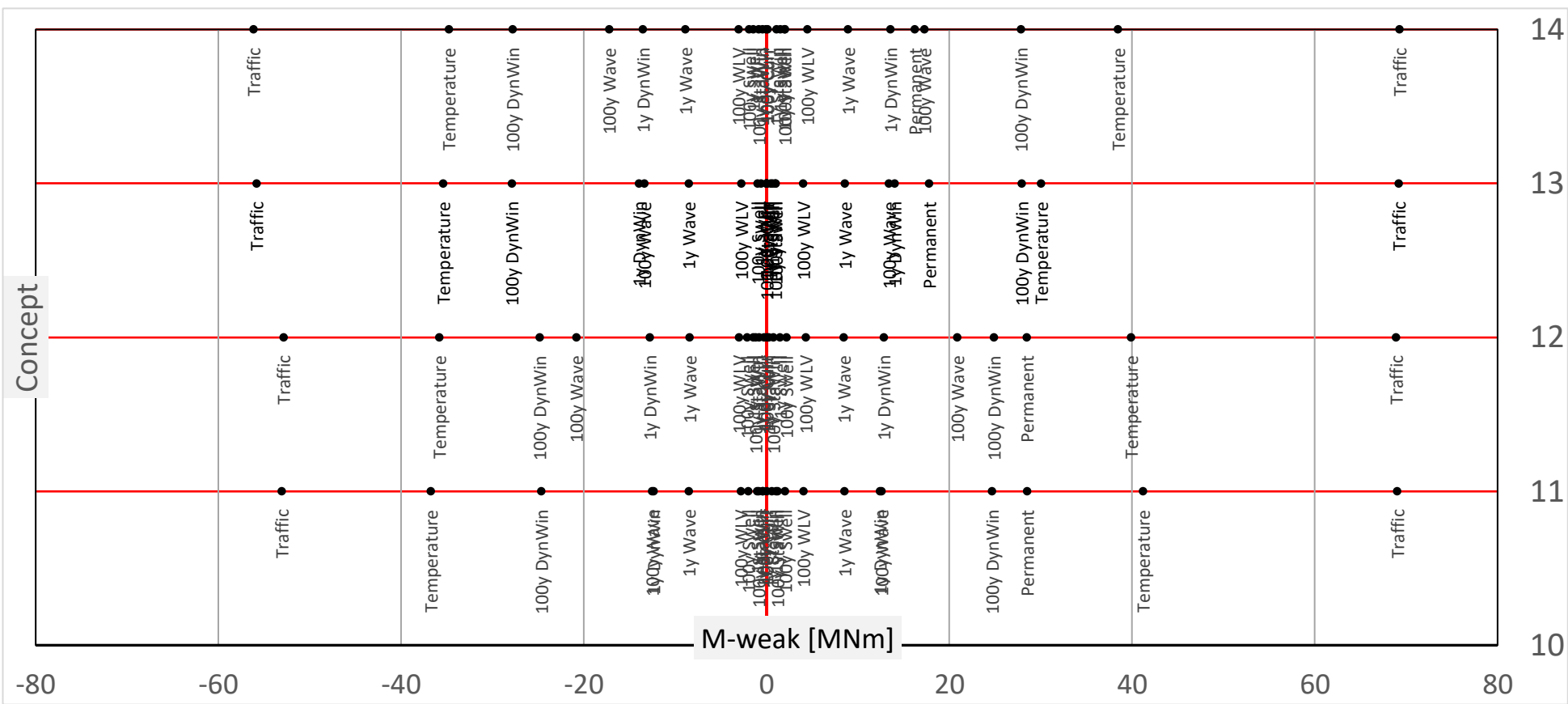
Model	Limit state	Criteria	Profile	Axial [MN]	M-strong [MNm]	M-weak [MNm]
K14_07	ULS3	_Worst_Min	38570	-45	-86	-140
		_Worst_Min	38625	-44	-284	-221
		_Worst_Min	38680	-42	-300	-101
		_Worst_Min	38735	-110	-206	-24
		_Worst_Min	38790	-156	-57	68
		_Worst_Max	38570	46	94	-206
		_Worst_Max	38625	42	308	-305
		_Worst_Max	38680	40	326	-198
		_Worst_Max	38735	-14	224	-153
		_Worst_Max	38790	-53	53	-112
	ULS2	_Worst_Min	38570	-34	-76	-139
		_Worst_Min	38625	-33	-169	-222
		_Worst_Min	38680	-31	-166	-90
		_Worst_Min	38735	-111	-118	0
		_Worst_Min	38790	-167	-59	107
		_Worst_Max	38570	33	80	-226
		_Worst_Max	38625	29	198	-331
		_Worst_Max	38680	26	201	-219
		_Worst_Max	38735	-30	145	-163
		_Worst_Max	38790	-68	64	-168
K12_06	ULS3	_Worst_Min	38570	-58	-135	-141
		_Worst_Min	38625	-58	-339	-225
		_Worst_Min	38680	-57	-428	-102
		_Worst_Min	38735	-122	-342	-17
		_Worst_Min	38790	-167	-58	47
		_Worst_Max	38570	51	134	-206
		_Worst_Max	38625	48	337	-296
		_Worst_Max	38680	47	426	-201
		_Worst_Max	38735	-10	342	-153
		_Worst_Max	38790	-49	60	-120
	ULS2	_Worst_Min	38570	-42	-106	-140
		_Worst_Min	38625	-41	-198	-225
		_Worst_Min	38680	-40	-235	-94
		_Worst_Min	38735	-118	-188	2
		_Worst_Min	38790	-174	-58	86
		_Worst_Max	38570	34	98	-227
		_Worst_Max	38625	30	203	-324
		_Worst_Max	38680	29	242	-218
		_Worst_Max	38735	-29	197	-156
		_Worst_Max	38790	-68	69	-180

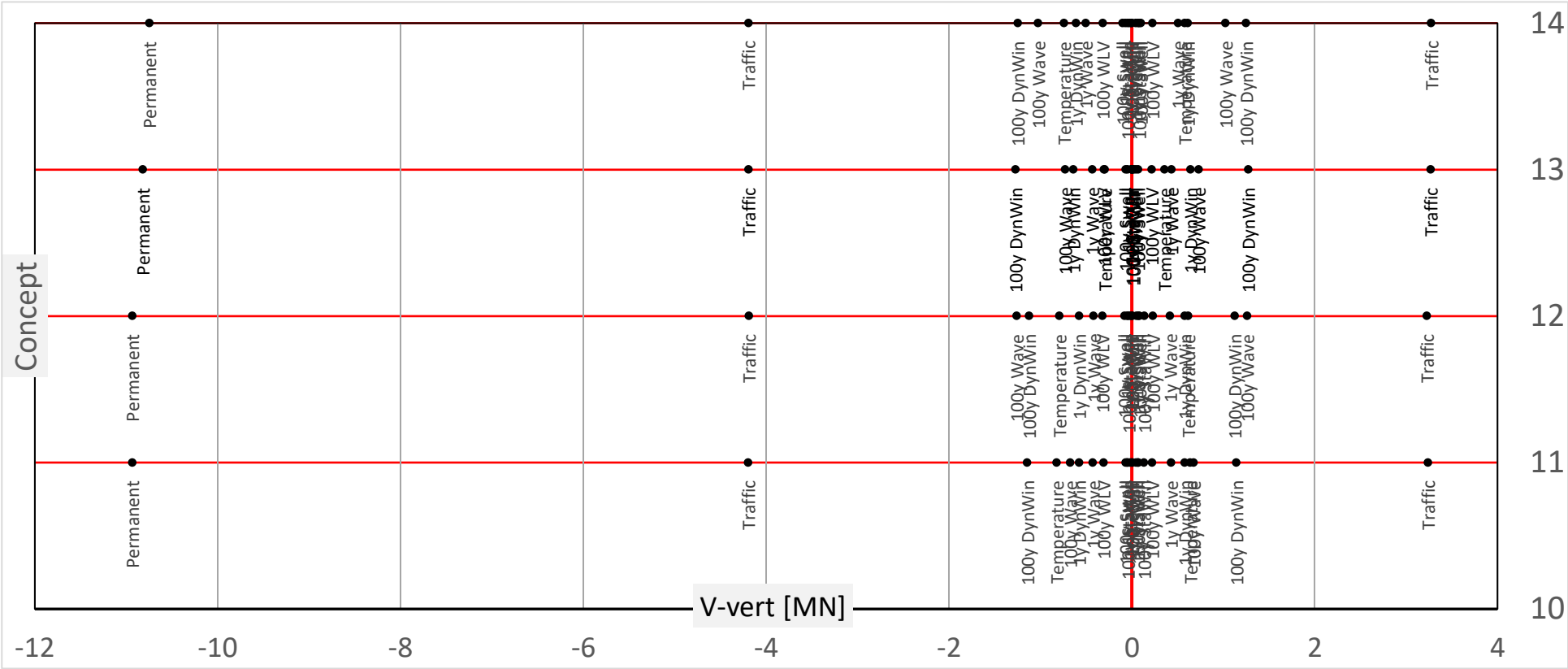
Model	Limit state	Criteria	Profile	Axial [MN]	M-strong [MNm]	M-weak [MNm]
K11_07	ALS-ship	Min M strong	BCE1	-43	-933	-13
		Min M weak	BCE1	-57	-471	-29
		Max M strong	BCE1	58	570	10
		Max M weak	BCE1	58	367	34
		Min M strong	BCE2	-45	-587	-15
		Min M weak	BCE2	-53	-333	-40
		Max M strong	BCE2	57	484	9
		Max M weak	BCE2	50	247	40
		Min M strong	BCE3	-45	-1186	-18
		Min M weak	BCE3	-60	-380	-29
		Max M strong	BCE3	44	873	12
		Max M weak	BCE3	62	367	30
		Min M strong	BCE4	-62	-2474	-14
		Min M weak	BCE4	-66	-1222	-37
		Max M strong	BCE4	56	2444	15
		Max M weak	BCE4	53	1305	35
		Min M strong	BCE5	-48	-2496	-22
		Min M weak	BCE5	-15	-2205	-71
		Max M strong	BCE5	64	3035	27
		Max M weak	BCE5	20	1328	89
K12_06	ALS-ship	Min M strong	BCE1	-29	-630	-8
		Min M weak	BCE1	-37	-324	-30
		Max M strong	BCE1	41	564	11
		Max M weak	BCE1	39	224	31
		Min M strong	BCE2	-44	-463	-7
		Min M weak	BCE2	-36	-276	-59
		Max M strong	BCE2	51	475	9
		Max M weak	BCE2	59	283	54
		Min M strong	BCE3	-26	-892	-27
		Min M weak	BCE3	-49	-645	-35
		Max M strong	BCE3	32	1014	9
		Max M weak	BCE3	39	966	38
		Min M strong	BCE4	-42	-1885	-7
		Min M weak	BCE4	-59	-1388	-31
		Max M strong	BCE4	33	2169	12
		Max M weak	BCE4	48	1654	26
		Min M strong	BCE5	-38	-2336	-25
		Min M weak	BCE5	-33	-1213	-69
		Max M strong	BCE5	52	2244	17
		Max M weak	BCE5	28	1189	85

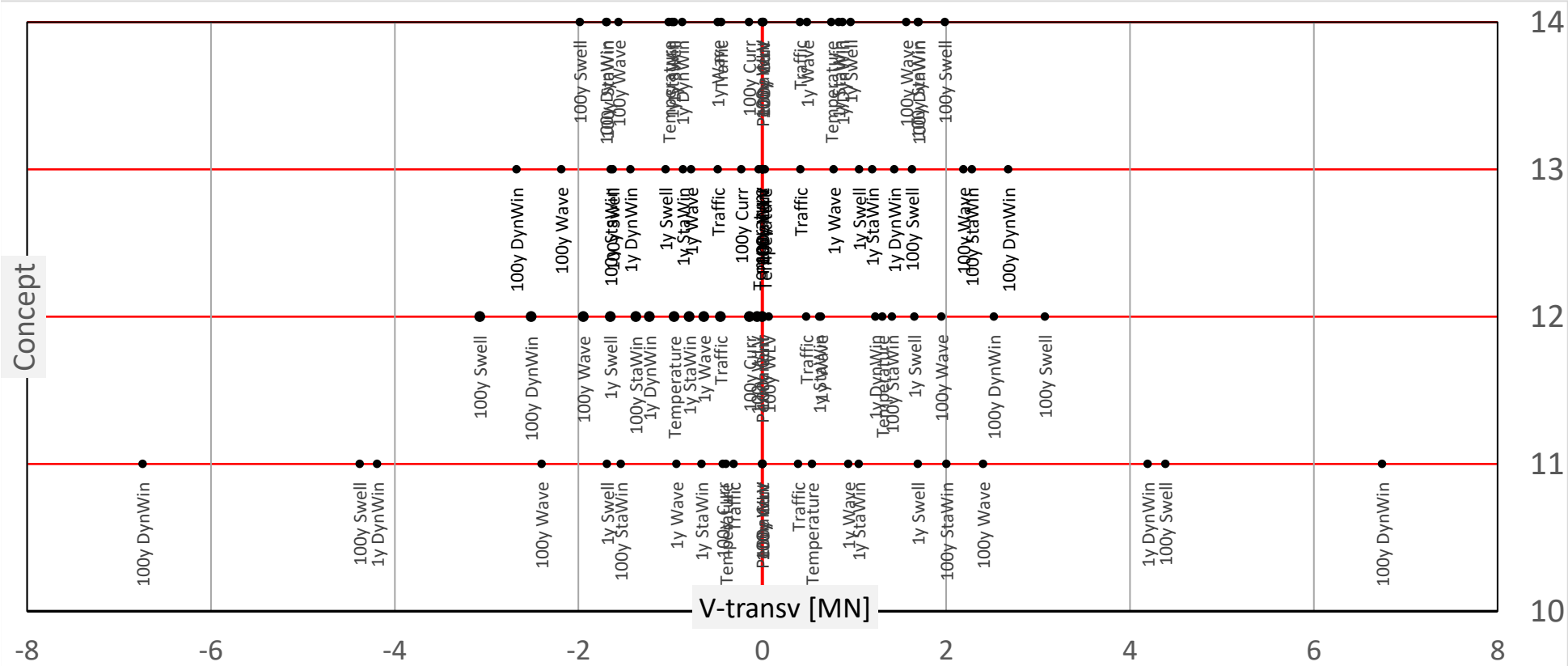
Model	Limit state	Criteria	Profile	Axial [MN]	M-strong [MNm]	M-weak [MNm]
K13_06	ALS-ship	Min M strong	BCE2	-18	-316	-17
		Min M weak	BCE2	-34	-160	-39
		Max M strong	BCE2	20	336	9
		Max M weak	BCE2	23	181	41
		Min M strong	BCE3	-16	-468	-11
		Min M weak	BCE3	-53	-209	-34
		Max M strong	BCE3	17	553	32
		Max M weak	BCE3	24	401	32
		Min M strong	BCE4	-11	-950	-18
		Min M weak	BCE4	-18	-475	-22
		Max M strong	BCE4	17	829	14
		Max M weak	BCE4	20	500	28
		Min M strong	BCE5	-11	-1275	-18
		Min M weak	BCE5	-12	-905	-67
		Max M strong	BCE5	31	1458	43
		Max M weak	BCE5	21	538	78
K14_07	ALS-ship	Min M strong	BCE1	-39	-262	-9
		Min M weak	BCE1	-55	-151	-20
		Max M strong	BCE1	48	253	6
		Max M weak	BCE1	41	166	17
		Min M strong	BCE2	-65	-335	-11
		Min M weak	BCE2	-51	-188	-22
		Max M strong	BCE2	43	355	6
		Max M weak	BCE2	59	145	23
		Min M strong	BCE3	-34	-289	-9
		Min M weak	BCE3	-47	-143	-18
		Max M strong	BCE3	33	327	6
		Max M weak	BCE3	43	115	16
		Min M strong	BCE4	-27	-603	-16
		Min M weak	BCE4	-54	-300	-23
		Max M strong	BCE4	45	664	8
		Max M weak	BCE4	63	364	27
		Min M strong	BCE5	-30	-1163	-53
		Min M weak	BCE5	-23	-480	-67
		Max M strong	BCE5	44	1142	28
		Max M weak	BCE5	14	779	86

Concept comparison - load actions - Support @ back column 5






Concept
V-vert [MN]
-12
-10
-8
-6
-4
-2
0
2
4
10
11
12
13
14
Permanent
Traffic
100y DynWin
100y Wave
Temperature
1y DynWin
1y Wave
100y WLV
100y Swell
1y Swell


Concept
V-transv [MN]
-8
-6
-4
-2
0
2
4
6
8
10
11
12
13
14
100y DynWin
100y Wave
100y Swell
1y DynWin
1y Swell
1y StaWin
100y StaWin
1y Wave
Temperature
Traffic
100y Curr
1y Curr

Construction stages - summary

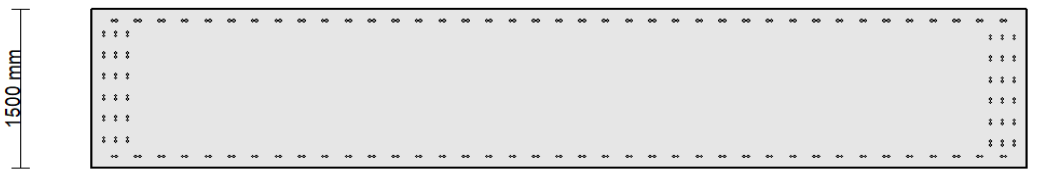
Phase	Limit state	Criteria	Criteria2	Axial [MN]2	M-strong [kNm]	M-weak [kNm]
BC1	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	3	8	-153
			Min	-3	-13	-202
	Phase c	ULS	Max	18	43	-140
			Min	-14	-61	-210
BC2	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	2	13	-182
			Min	-3	-23	-242
	Phase c	ULS	Max	18	147	-184
			Min	-14	-104	-266
BC3	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	2	13	-164
			Min	-2	-24	-220
	Phase c	ULS	Max	11	360	-70
			Min	-21	-239	-161
BC4	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	1	18	-219
			Min	-2	-21	-287
	Phase c	ULS	Max	-23	459	-56
			Min	-68	-308	-158
BC5	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-1	0	-31
			Min	-2	0	-51
	Phase c	ULS	Max	-47	184	53
			Min	-111	-125	-111

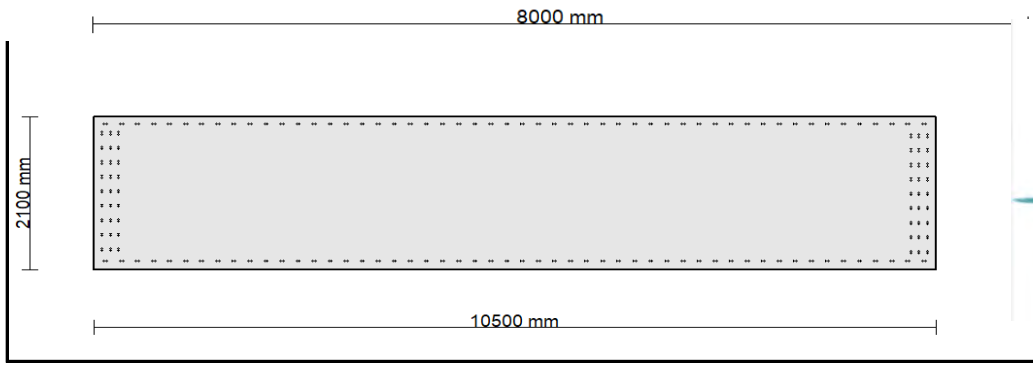
Capacity diagrams

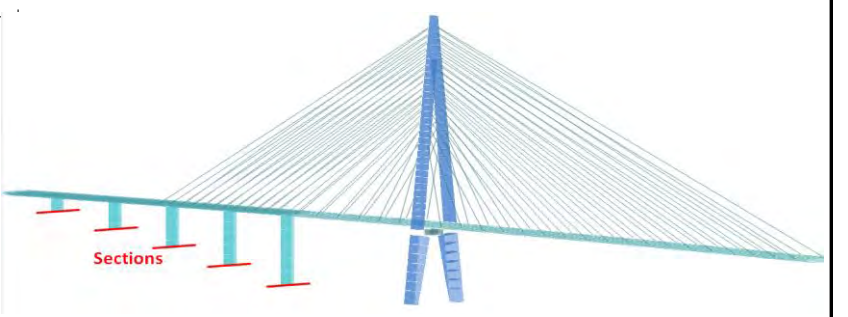
Elevation Back column

Title	Back column x*y=1.5*8 mass.	
Ac	1.20E+07	mm2
Ix	2.25E+12	mm4
Iy	6.40E+13	mm4
As	1.83E+05	mm2
rho	1.5 %	
	2ø32c200	3 layers short edge
Title	Back column x*y=2.1*10.5 mass.	
Ac	2.21E+07	mm2
Ix	8.10E+12	mm4
Iy	2.03E+14	mm4
As	2.54E+05	mm2
rho	1.2 %	
	2ø32c200	3 layers short edge

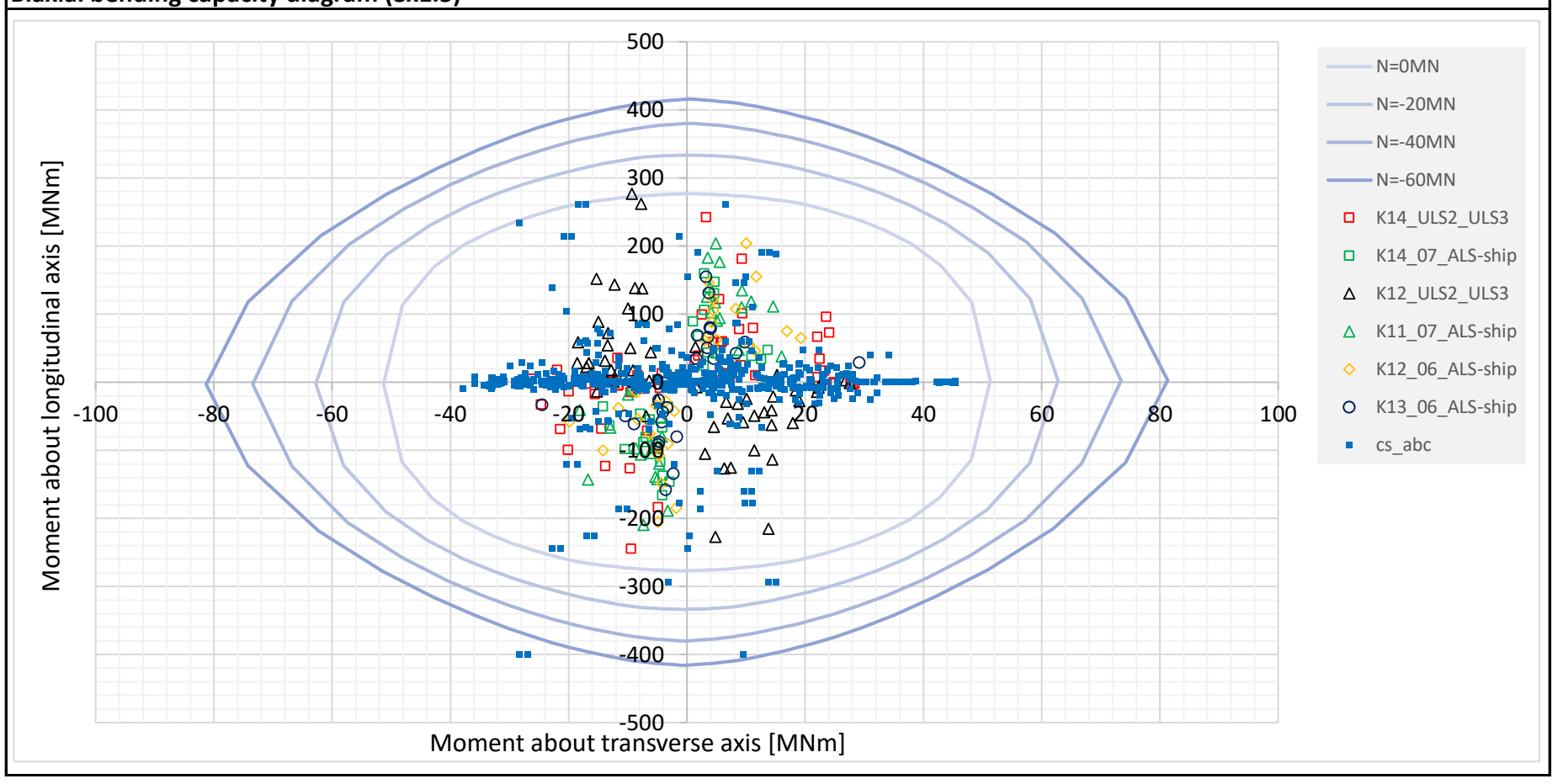
Project	Bjørnafjorden phase 5
Date	25.06.2019
By	Petter Buckholm
Models	K11_07 (ULS/ALS)
	K12_06 (ULS/ALS)
	K13_06 (ULS/ALS)
	K14_07 (ULS/ALS)
	C.S. a,b,c, all wind.dir.
	(results dated 24.06.2019)
	For CS calculations, analyses
	are based on sect 10.5m*2.1m



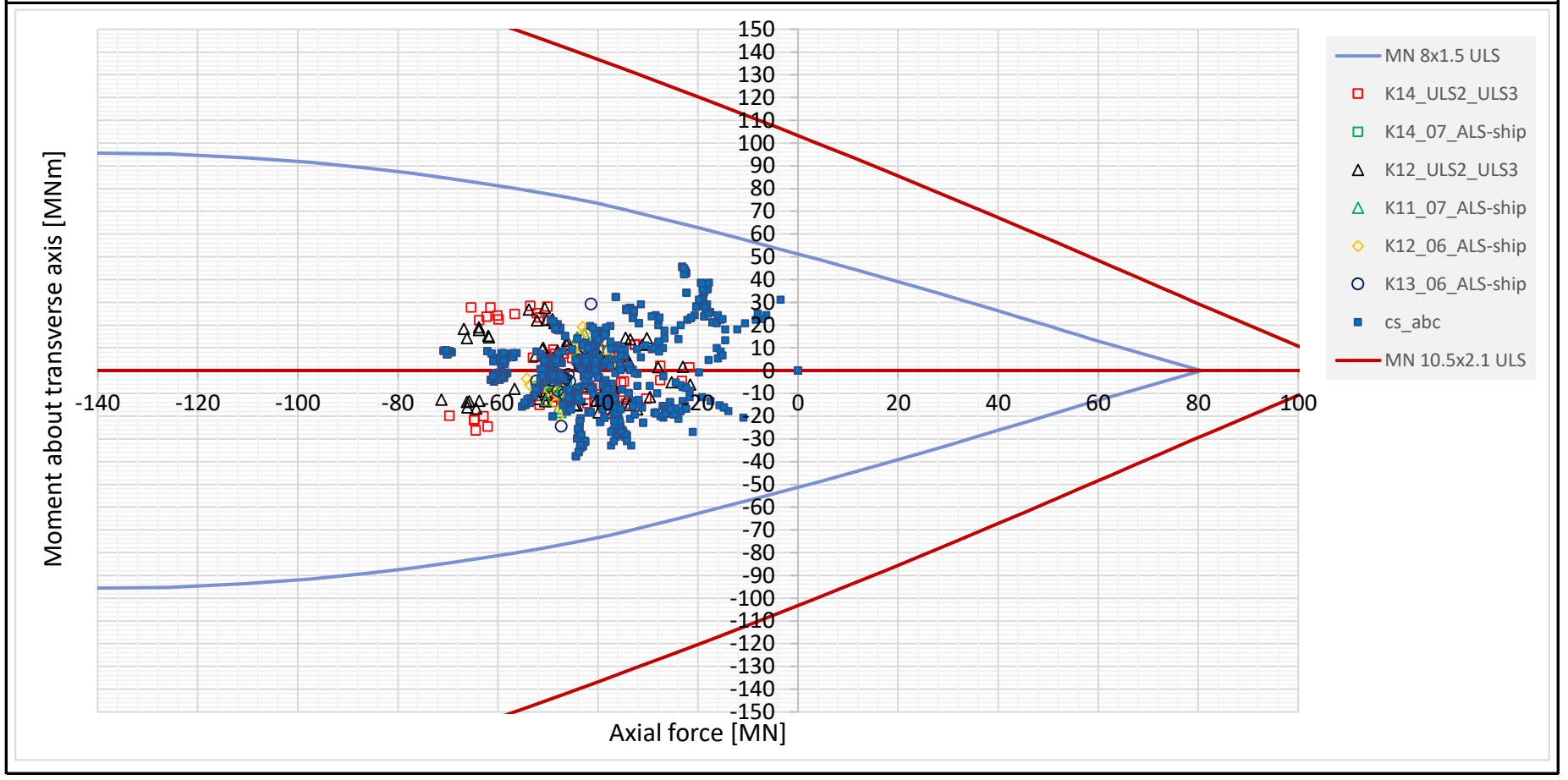




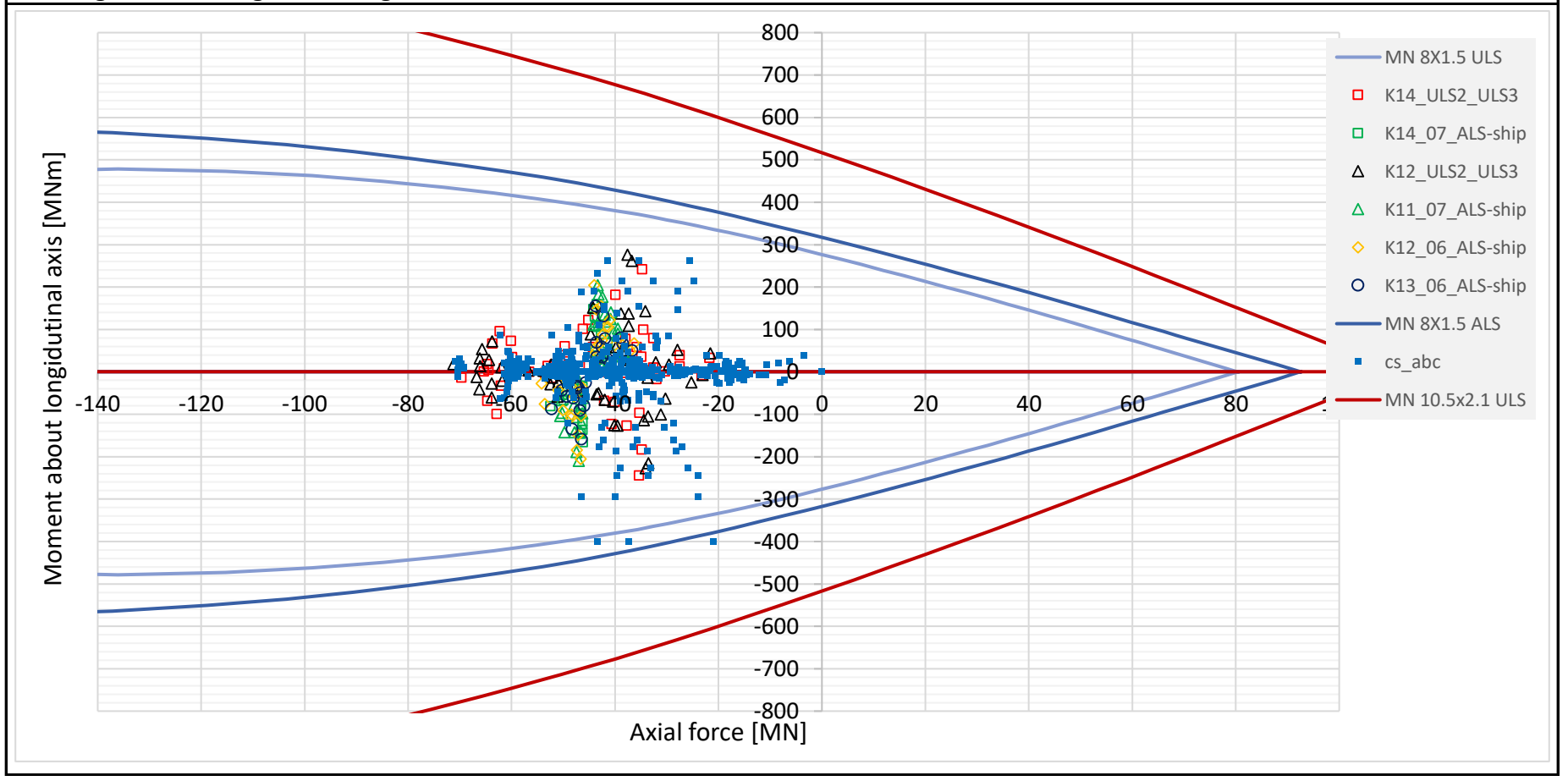
Biaxial bending capacity diagram (8x1.5)



MN-diagram - bending about transverse axis



MN-diagram - bending about longitudinal axis



Design loads

Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K14_07	ULS3	Min N	BCE1 bottom	-52	25	-2
		Min N	BCE2 bottom	-65	-22	18
		Min N	BCE3 bottom	-50	6	60
		Min N	BCE4 bottom	-46	9	101
		Min N	BCE5 bottom	-42	-8	10
		Min M longit	BCE1 bottom	-50	-8	-9
		Min M longit	BCE2 bottom	-63	-20	-99
		Min M longit	BCE3 bottom	-41	-14	-123
		Min M longit	BCE4 bottom	-35	-5	-184
		Min M longit	BCE5 bottom	-35	-9	-245
		Min M transv	BCE1 bottom	-49	-14	1
		Min M transv	BCE2 bottom	-62	-25	-33
		Min M transv	BCE3 bottom	-37	-16	9
		Min M transv	BCE4 bottom	-40	-7	-71
		Min M transv	BCE5 bottom	-35	-12	35
		Max N	BCE1 bottom	-49	-12	-4
		Max N	BCE2 bottom	-60	24	73
		Max N	BCE3 bottom	-34	-15	2
		Max N	BCE4 bottom	-27	-4	13
		Max N	BCE5 bottom	-27	2	39
		Max M longit	BCE1 bottom	-50	22	7
		Max M longit	BCE2 bottom	-62	24	96
		Max M longit	BCE3 bottom	-45	5	122
		Max M longit	BCE4 bottom	-40	9	181
		Max M longit	BCE5 bottom	-35	3	242
		Max M transv	BCE1 bottom	-50	28	-4
		Max M transv	BCE2 bottom	-61	28	8
		Max M transv	BCE3 bottom	-47	7	13
		Max M transv	BCE4 bottom	-33	11	80
		Max M transv	BCE5 bottom	-36	6	58
	ULS2	Min N	BCE1 bottom	-57	25	0
		Min N	BCE2 bottom	-70	-20	-14
		Min N	BCE3 bottom	-53	6	13
		Min N	BCE4 bottom	-49	9	25
		Min N	BCE5 bottom	-49	-7	-9
		Min M longit	BCE1 bottom	-52	-9	-15
		Min M longit	BCE2 bottom	-65	-21	-69
		Min M longit	BCE3 bottom	-42	-14	-69
		Min M longit	BCE4 bottom	-35	-5	-96
		Min M longit	BCE5 bottom	-38	-10	-126
		Min M transv	BCE1 bottom	-52	-15	2
		Min M transv	BCE2 bottom	-64	-26	5
		Min M transv	BCE3 bottom	-38	-17	-2
		Min M transv	BCE4 bottom	-41	-8	-2
		Min M transv	BCE5 bottom	-30	-12	1
		Max N	BCE1 bottom	-48	-12	-5
		Max N	BCE2 bottom	-60	22	34
		Max N	BCE3 bottom	-32	-16	-17
		Max N	BCE4 bottom	-23	-5	-9
		Max N	BCE5 bottom	-22	1	33
		Max M longit	BCE1 bottom	-52	23	17
		Max M longit	BCE2 bottom	-64	22	66
		Max M longit	BCE3 bottom	-44	4	59
		Max M longit	BCE4 bottom	-38	9	78
		Max M longit	BCE5 bottom	-35	3	99
		Max M transv	BCE1 bottom	-54	28	-3
		Max M transv	BCE2 bottom	-65	28	1
		Max M transv	BCE3 bottom	-49	7	7
		Max M transv	BCE4 bottom	-33	12	10
		Max M transv	BCE5 bottom	-42	6	10

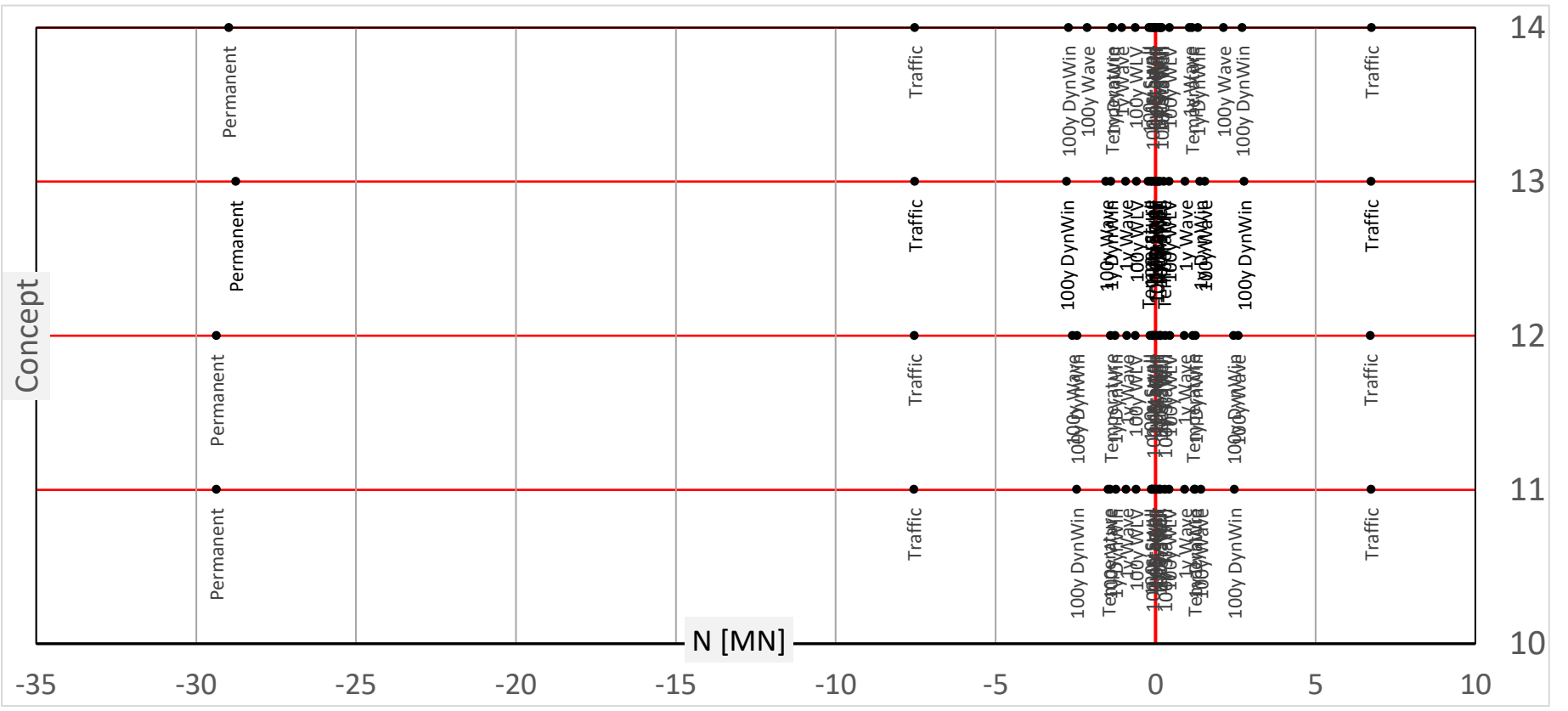
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K12_06	ULS3	Min N	BCE1 bottom	-52	-9	2
		Min N	BCE2 bottom	-66	-14	32
		Min N	BCE3 bottom	-51	10	-59
		Min N	BCE4 bottom	-46	13	-44
		Min N	BCE5 bottom	-43	-7	-50
		Min M longit	BCE1 bottom	-50	22	-8
		Min M longit	BCE2 bottom	-64	18	-60
		Min M longit	BCE3 bottom	-40	7	-126
		Min M longit	BCE4 bottom	-34	14	-215
		Min M longit	BCE5 bottom	-34	5	-227
		Min M transv	BCE1 bottom	-51	-13	1
		Min M transv	BCE2 bottom	-64	-17	28
		Min M transv	BCE3 bottom	-40	-18	58
		Min M transv	BCE4 bottom	-37	-10	108
		Min M transv	BCE5 bottom	-34	-12	143
		Max N	BCE1 bottom	-49	23	-1
		Max N	BCE2 bottom	-62	15	11
		Max N	BCE3 bottom	-34	-15	-14
		Max N	BCE4 bottom	-25	-5	-25
		Max N	BCE5 bottom	-28	1	52
		Max M longit	BCE1 bottom	-50	-11	7
		Max M longit	BCE2 bottom	-64	-13	72
		Max M longit	BCE3 bottom	-44	-15	152
		Max M longit	BCE4 bottom	-37	-8	262
		Max M longit	BCE5 bottom	-38	-9	277
		Max M transv	BCE1 bottom	-51	28	-1
		Max M transv	BCE2 bottom	-64	19	-28
		Max M transv	BCE3 bottom	-51	10	-24
		Max M transv	BCE4 bottom	-34	14	-114
		Max M transv	BCE5 bottom	-40	6	-127
	ULS2	Min N	BCE1 bottom	-57	-8	4
		Min N	BCE2 bottom	-71	-13	18
		Min N	BCE3 bottom	-52	7	-29
		Min N	BCE4 bottom	-46	11	-49
		Min N	BCE5 bottom	-49	-6	2
		Min M longit	BCE1 bottom	-52	22	-14
		Min M longit	BCE2 bottom	-66	14	-41
		Min M longit	BCE3 bottom	-42	5	-65
		Min M longit	BCE4 bottom	-31	11	-100
		Min M longit	BCE5 bottom	-34	3	-105
		Min M transv	BCE1 bottom	-52	-12	1
		Min M transv	BCE2 bottom	-66	-16	13
		Min M transv	BCE3 bottom	-37	-19	28
		Min M transv	BCE4 bottom	-39	-10	50
		Min M transv	BCE5 bottom	-30	-12	17
		Max N	BCE1 bottom	-49	21	-2
		Max N	BCE2 bottom	-62	15	-21
		Max N	BCE3 bottom	-32	-17	22
		Max N	BCE4 bottom	-22	-6	44
		Max N	BCE5 bottom	-23	2	-8
		Max M longit	BCE1 bottom	-52	-9	17
		Max M longit	BCE2 bottom	-66	-13	54
		Max M longit	BCE3 bottom	-45	-15	88
		Max M longit	BCE4 bottom	-37	-8	138
		Max M longit	BCE5 bottom	-39	-9	138
		Max M transv	BCE1 bottom	-54	27	2
		Max M transv	BCE2 bottom	-67	18	-12
		Max M transv	BCE3 bottom	-48	9	-32
		Max M transv	BCE4 bottom	-30	14	-63
		Max M transv	BCE5 bottom	-44	7	-53

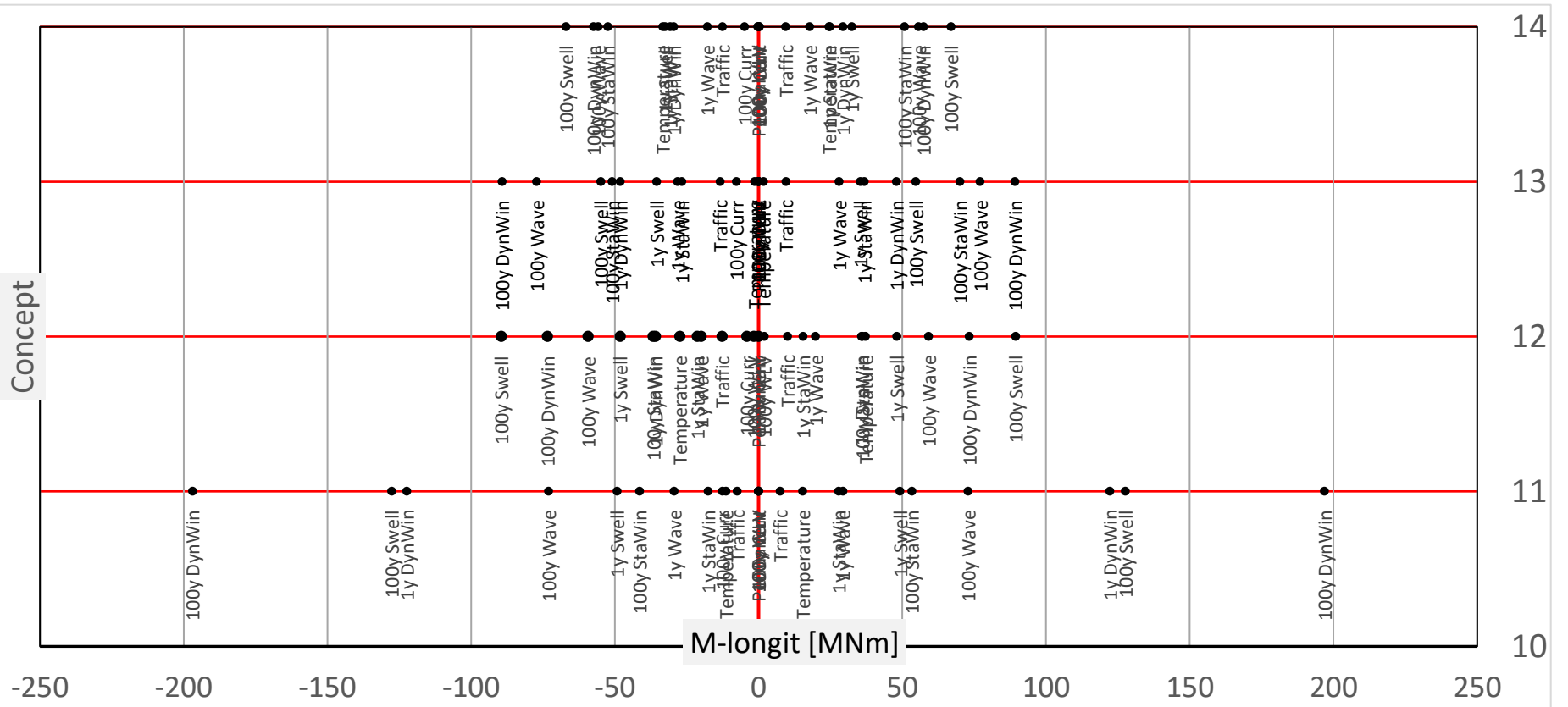
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K14_07	ULS3	_Worst_Min	BCE1 bottom	-51	-15	-7
		_Worst_Min	BCE2 bottom	-64	-26	-78
		_Worst_Min	BCE3 bottom	-50	-16	-95
		_Worst_Min	BCE4 bottom	-48	-7	-140
		_Worst_Min	BCE5 bottom	-42	-12	-187
		_Worst_Max	BCE1 bottom	-48	27	7
		_Worst_Max	BCE2 bottom	-59	26	72
		_Worst_Max	BCE3 bottom	-34	7	87
		_Worst_Max	BCE4 bottom	-28	11	129
		_Worst_Max	BCE5 bottom	-28	5	172
	ULS2	_Worst_Min	BCE1 bottom	-56	-15	-14
		_Worst_Min	BCE2 bottom	-69	-26	-61
		_Worst_Min	BCE3 bottom	-53	-17	-58
		_Worst_Min	BCE4 bottom	-49	-8	-80
		_Worst_Min	BCE5 bottom	-49	-13	-104
		_Worst_Max	BCE1 bottom	-48	28	17
		_Worst_Max	BCE2 bottom	-59	27	63
		_Worst_Max	BCE3 bottom	-32	7	54
		_Worst_Max	BCE4 bottom	-23	11	69
		_Worst_Max	BCE5 bottom	-22	6	87
K12_06	ULS3	_Worst_Min	BCE1 bottom	-51	-13	-8
		_Worst_Min	BCE2 bottom	-65	-16	-63
		_Worst_Min	BCE3 bottom	-50	-18	-129
		_Worst_Min	BCE4 bottom	-46	-9	-219
		_Worst_Min	BCE5 bottom	-43	-11	-230
		_Worst_Max	BCE1 bottom	-48	25	8
		_Worst_Max	BCE2 bottom	-61	17	63
		_Worst_Max	BCE3 bottom	-33	8	129
		_Worst_Max	BCE4 bottom	-25	13	220
		_Worst_Max	BCE5 bottom	-28	5	231
	ULS2	_Worst_Min	BCE1 bottom	-56	-12	-14
		_Worst_Min	BCE2 bottom	-71	-16	-45
		_Worst_Min	BCE3 bottom	-52	-19	-74
		_Worst_Min	BCE4 bottom	-46	-10	-115
		_Worst_Min	BCE5 bottom	-49	-12	-121
		_Worst_Max	BCE1 bottom	-48	26	18
		_Worst_Max	BCE2 bottom	-61	18	51
		_Worst_Max	BCE3 bottom	-32	8	79
		_Worst_Max	BCE4 bottom	-22	14	121
		_Worst_Max	BCE5 bottom	-23	7	121

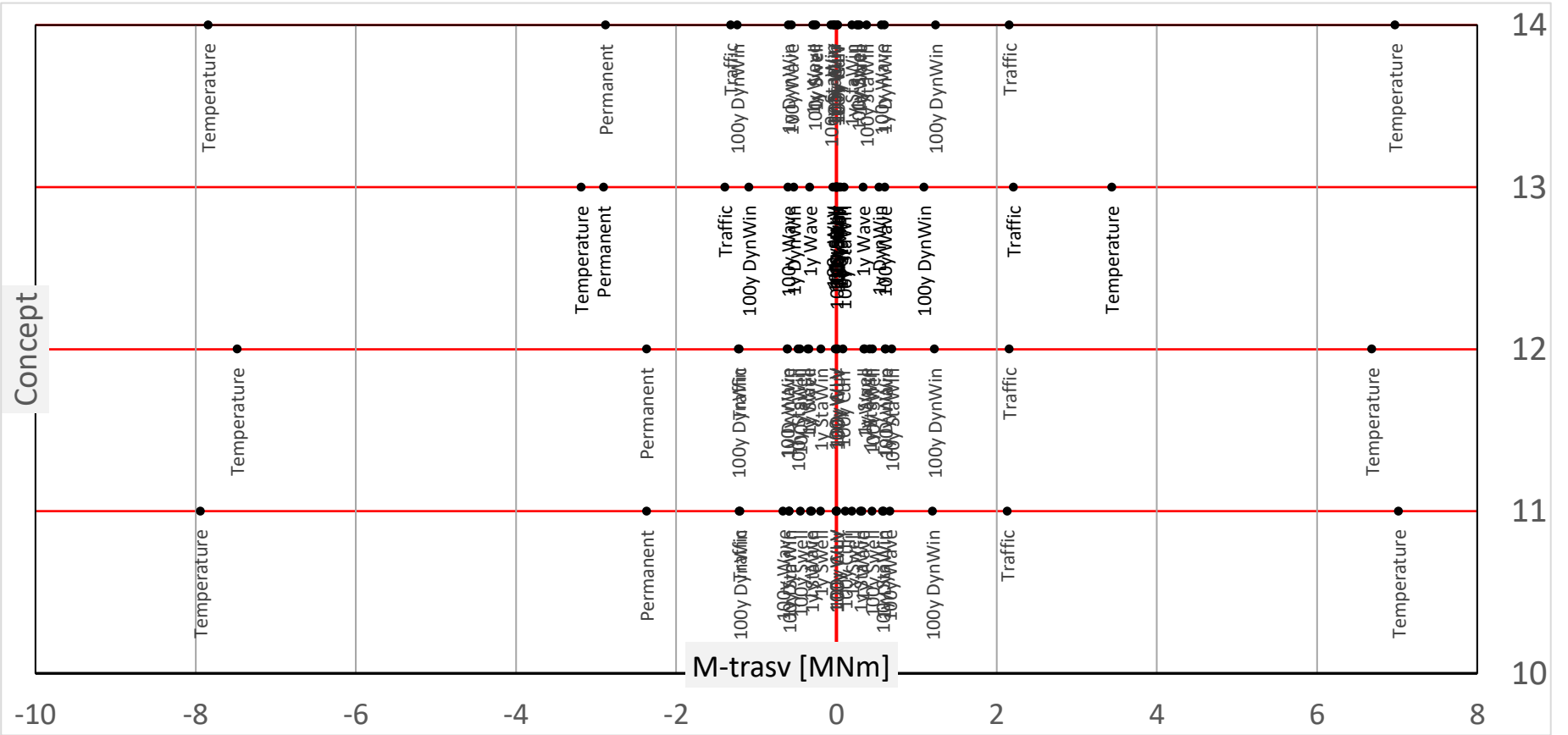
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K11_07	ALS-ship	Min N	BCE1 bottom	-51	-4	-51
		Min M longit	BCE1 bottom	-48	-4	-80
		Min M transv	BCE1 bottom	-47	-10	-18
		Max N	BCE1 bottom	-39	4	102
		Max M longit	BCE1 bottom	-41	4	140
		Max M transv	BCE1 bottom	-42	11	119
		Min N	BCE2 bottom	-50	-5	-97
		Min M longit	BCE2 bottom	-47	-5	-139
		Min M transv	BCE2 bottom	-47	-8	-106
		Max N	BCE2 bottom	-40	6	94
		Max M longit	BCE2 bottom	-42	6	177
		Max M transv	BCE2 bottom	-42	9	135
		Min N	BCE3 bottom	-50	-5	-142
		Min M longit	BCE3 bottom	-47	-3	-189
		Min M transv	BCE3 bottom	-46	-9	-98
		Max N	BCE3 bottom	-41	3	125
		Max M longit	BCE3 bottom	-43	4	183
		Max M transv	BCE3 bottom	-43	9	110
		Min N	BCE4 bottom	-51	-6	-104
		Min M longit	BCE4 bottom	-47	-7	-210
		Min M transv	BCE4 bottom	-48	-17	-143
		Max N	BCE4 bottom	-39	5	90
		Max M longit	BCE4 bottom	-43	5	204
		Max M transv	BCE4 bottom	-44	15	111
		Min N	BCE5 bottom	-50	-13	-67
		Min M longit	BCE5 bottom	-47	-5	-120
		Min M transv	BCE5 bottom	-47	-18	-41
		Max N	BCE5 bottom	-38	9	47
		Max M longit	BCE5 bottom	-43	5	118
		Max M transv	BCE5 bottom	-43	16	38
K12_06	ALS-ship	Min N	BCE1 bottom	-54	-4	-28
		Min M longit	BCE1 bottom	-49	-5	-108
		Min M transv	BCE1 bottom	-50	-9	-15
		Max N	BCE1 bottom	-36	3	67
		Max M longit	BCE1 bottom	-41	4	122
		Max M transv	BCE1 bottom	-42	8	108
		Min N	BCE2 bottom	-49	-5	-34
		Min M longit	BCE2 bottom	-47	-4	-149
		Min M transv	BCE2 bottom	-47	-8	-54
		Max N	BCE2 bottom	-42	4	88
		Max M longit	BCE2 bottom	-44	4	146
		Max M transv	BCE2 bottom	-44	10	56
		Min N	BCE3 bottom	-50	-3	-91
		Min M longit	BCE3 bottom	-47	-2	-185
		Min M transv	BCE3 bottom	-48	-20	-58
		Max N	BCE3 bottom	-40	3	61
		Max M longit	BCE3 bottom	-43	12	155
		Max M transv	BCE3 bottom	-43	19	65
		Min N	BCE4 bottom	-54	-6	-76
		Min M longit	BCE4 bottom	-47	-5	-205
		Min M transv	BCE4 bottom	-48	-14	-100
		Max N	BCE4 bottom	-37	5	49
		Max M longit	BCE4 bottom	-44	10	204
		Max M transv	BCE4 bottom	-43	17	75
		Min N	BCE5 bottom	-51	-2	-43
		Min M longit	BCE5 bottom	-47	-5	-104
		Min M transv	BCE5 bottom	-46	-12	-38
		Max N	BCE5 bottom	-39	5	63
		Max M longit	BCE5 bottom	-41	4	106
		Max M transv	BCE5 bottom	-44	12	46

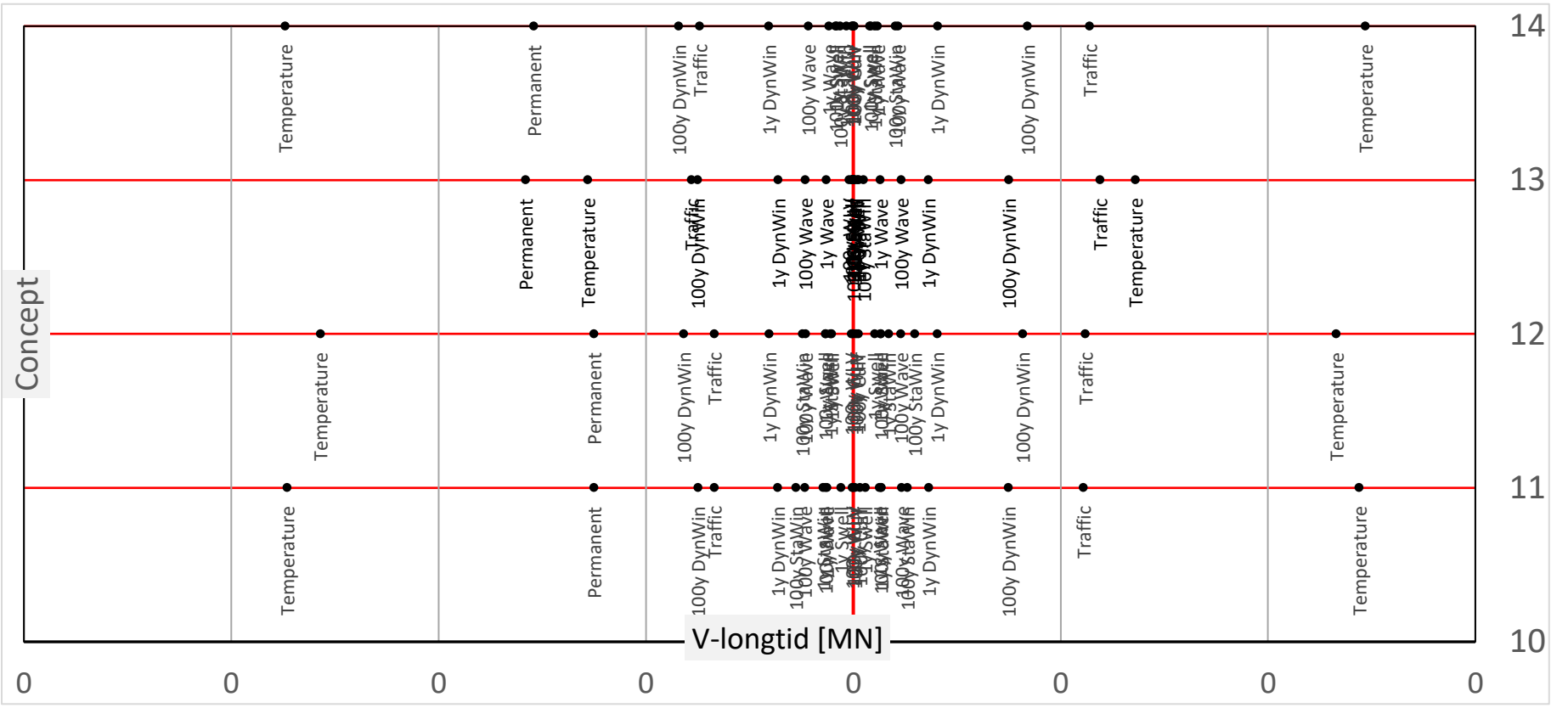
Model	Limit state	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
K13_06	ALS-ship	Min N	BCE1 bottom	-47	-3	-37
		Min M longit	BCE1 bottom	-46	-2	-80
		Min M transv	BCE1 bottom	-46	-5	-26
		Max N	BCE1 bottom	-42	2	34
		Max M longit	BCE1 bottom	-44	2	69
		Max M transv	BCE1 bottom	-44	5	35
		Min N	BCE2 bottom	-52	-5	-87
		Min M longit	BCE2 bottom	-46	-4	-158
		Min M transv	BCE2 bottom	-48	-9	-62
		Max N	BCE2 bottom	-37	3	50
		Max M longit	BCE2 bottom	-44	3	155
		Max M transv	BCE2 bottom	-41	8	42
		Min N	BCE3 bottom	-49	-4	-59
		Min M longit	BCE3 bottom	-48	-2	-135
		Min M transv	BCE3 bottom	-47	-10	-50
		Max N	BCE3 bottom	-39	4	80
		Max M longit	BCE3 bottom	-42	4	131
		Max M transv	BCE3 bottom	-43	10	58
		Min N	BCE4 bottom	-50	-4	-44
		Min M longit	BCE4 bottom	-47	-5	-91
		Min M transv	BCE4 bottom	-47	-25	-33
		Max N	BCE4 bottom	-38	4	66
		Max M longit	BCE4 bottom	-42	4	79
		Max M transv	BCE4 bottom	-41	29	29
K14_07	ALS-ship	Min N	BCE1 bottom	-49	-3	-36
		Min M longit	BCE1 bottom	-47	-5	-88
		Min M transv	BCE1 bottom	-46	-9	-12
		Max N	BCE1 bottom	-41	3	24
		Max M longit	BCE1 bottom	-43	1	89
		Max M transv	BCE1 bottom	-43	9	13
		Min N	BCE2 bottom	-49	-8	-47
		Min M longit	BCE2 bottom	-46	-4	-166
		Min M transv	BCE2 bottom	-47	-10	-98
		Max N	BCE2 bottom	-41	5	42
		Max M longit	BCE2 bottom	-44	5	147
		Max M transv	BCE2 bottom	-43	11	39
		Min N	BCE3 bottom	-50	-4	-67
		Min M longit	BCE3 bottom	-46	-4	-137
		Min M transv	BCE3 bottom	-47	-7	-88
		Max N	BCE3 bottom	-41	2	68
		Max M longit	BCE3 bottom	-44	5	130
		Max M transv	BCE3 bottom	-43	8	29
		Min N	BCE4 bottom	-52	-7	-81
		Min M longit	BCE4 bottom	-47	-3	-146
		Min M transv	BCE4 bottom	-46	-13	-64
		Max N	BCE4 bottom	-38	5	42
		Max M longit	BCE4 bottom	-43	3	160
		Max M transv	BCE4 bottom	-40	13	34
		Min N	BCE5 bottom	-50	-6	-55
		Min M longit	BCE5 bottom	-46	-4	-117
		Min M transv	BCE5 bottom	-46	-14	-35
		Max N	BCE5 bottom	-38	4	43
		Max M longit	BCE5 bottom	-44	3	106
		Max M transv	BCE5 bottom	-44	14	48

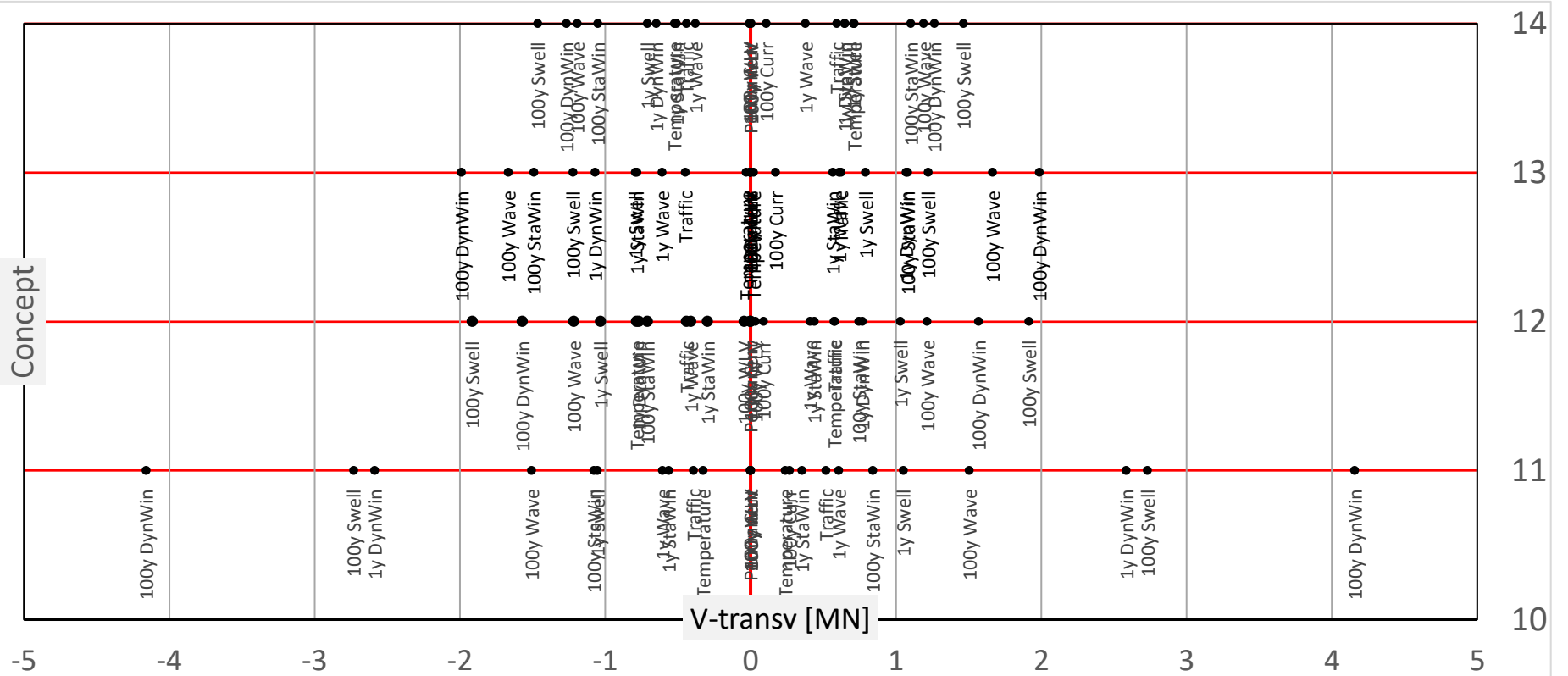
Concept comparson - load actions - Back column BCE5 bottom








Concept
V-longtid [MN]
14
13
12
11
10
0
Temperature
Permanent
Traffic
100y DynWin
1y DynWin
100y Wave
1y Wave
100y StaWin
1y Swell


Concept
V-transv [MN]
14
13
12
11
10
-5
-4
-3
-2
-1
0
1
2
3
4
5
100y DynWin
100y Swell
1y DynWin
100y Wave
1y Swell
1y Wave
100y StaWin
1y StaWin
Traffic
Temperature
100y Curr
1y Wave
1y Swell

Construction stages - summary

Sect	Phase	Criteria	Criteria2	Axial [MN]	BMTA [MNm]	BMLA [MNm]
BC1 bot	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-39	19	11
			Min	-49	12	-11
	Phase c	ULS	Max	-38	22	47
			Min	-49	6	-33
BC1 top	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-35	-21	5
			Min	-44	-34	-5
	Phase c	ULS	Max	-33	-14	8
			Min	-44	-38	-10
BC2 bot	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-47	1	19
			Min	-60	-4	-12
	Phase c	ULS	Max	-47	9	87
			Min	-62	-7	-64
BC2 top	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-40	6	5
			Min	-51	-3	-5
	Phase c	ULS	Max	-40	9	12
			Min	-54	-14	-15
BC3 bot	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-48	1	22
			Min	-61	-4	-11
	Phase c	ULS	Max	-29	-2	104
			Min	-49	-20	-121
BC3 top	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-38	5	2
			Min	-49	-1	-2
	Phase c	ULS	Max	-18	32	13
			Min	-36	6	-16
BC4 bot	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-56	9	30
			Min	-71	2	-11
	Phase c	ULS	Max	-24	15	191
			Min	-47	-3	-294
BC4 top	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-43	-9	1
			Min	-55	-16	-1
	Phase c	ULS	Max	-11	-3	6
			Min	-31	-23	-7
BC5 bot	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-35	-11	28
			Min	-44	-30	-11
	Phase c	ULS	Max	-21	9	262
			Min	-43	-28	-401
BC5 top	Phase a	ULS	Max	0	0	0
			Min	0	0	0
	Phase b	ULS	Max	-18	45	1
			Min	-23	28	-1
	Phase c	ULS	Max	-3	34	39
			Min	-22	-1	-26

Concept development, floating bridge
E39 Bjørnafjorden

Appendix L – Enclosure 2

Foundation stresses

ENCLOSURE L2

PROJECT	Concept development, floating bridge E39 Bjørnafjorden	DOCUMENT CODE	SBJ-33-C5-AMC-22-RE-112
CLIENT	Statens vegvesen	ACCESSIBILITY	Restricted
SUBJECT	Foundation stability and stresses	PROJECT MANAGER	Svein Erik Jakobsen
TO		PREPARED BY	Arne Munz / Adrian Wike Dahlen
COPY TO		RESPONSIBLE UNIT	AMC

SUMMARY

This Enclosure to Appendix L deals with foundation stability of the tower and back columns of the cable stayed bridge. Critical constructions stages and complete states are evaluated.

All stability checks are OK for the proposed foundation dimensions.

- Constructions stages are governing for the tower.
- Constructions stages are governing for the axis 1E column, and ship collision is governing for the other back columns.

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3 Stability checks back columns complete states 7

4 Stability checks tower construction stages 15

5 Stability checks tower complete states 27

0	15.08.2019	Final issue	AWD / AMU	AMU	AMU
REV.	DATE	DESCRIPTION	PREPARED BY	CHECKED BY	APPROVED BY

1 Introduction

This Enclosure shows stability checks of the back columns and tower of the cable stayed bridge for critical construction stages and the complete states.

Reference is made to Enclosure L3 for the analysis of construction stages, to Appendix G for the global analysis of the complete state, and Appendix J for ship collision.

Stability checks performed:

- Ground pressure is checked acc. to N400 11.2.3. Should be < 10MPa.
- Gliding is checked acc. to N400 11.2.5. Torsional moment is not taken into account.
- Overturning is checked acc. to N400 11.2.1.
- Eccentricities also checked in SLS acc. to N400 11.2.2.

For back columns and the complete states of the tower only checks of ground pressure is included.

Foundation dimensions acc. to drawings:

- Back columns axis 1A- 1C → 7m x 15m x 3m
- Back column axis 1D → 7m x 18m x 3m
- Back column axis 1E → 8m x 18m x 3m
- Tower legs axis 2 → 21m x 10m x 5.5m

This Enclosure is structured as follows:

Chapter 2: Stability checks back columns construction stages

Evaluated stages:

- A1. The last stage of casting the column in axis 1E

Checked for both uncracked and cracked concrete ($0.4xE_{uncracked}$) of all column elements. Only wind from south included as it is clearly the most critical case.

Chapter 3: Stability checks back columns complete states

- ULS2
- ULS3
- PLS Ship collision

Chapter 4: Stability checks tower construction stages

Evaluated stages:

- A2. The last stage of casting the tower in axis 2
- B. Cantilevered situation of cable stayed bridge before closing at the side span
- C. Cantilevered bridge girder in main span before before closing in axis 3

Checked for both uncracked and cracked concrete ($0.4xE_{uncracked}$) of all tower elements.

Chapter 5: Stability checks tower complete states

- ULS2
- ULS3
- PLS Ship collision

2 Stability checks back columns construction stages

Analysis of construction stages

K12

Ground pressure side span column 1E ULS

Wind on free standing columns during construction

Forces from analysis

		Min N				Foundation sizes				eccentrivcity				ground pressure
		N	**M longit**	**M transv**	**T**	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	**MNm**	**MNm**	**MNm**	m	m	m	KN	MN	m	m	m2	Mpa
tag	**pos**													
urisset	**0**	-42.50	31.70	154.60	0.00	8	18	3	0	-42.50	3.64	0.75	11.96	-3.55
risset	**0**	-42.50	35.00	152.60	0.00	8	18	3	0	-42.50	3.59	0.82	13.39	-3.17

Used formulaes:

N=Nanalysis+DN (N from analysis+weight from foundation)
el=Mtransv/N eccentricity in longitudinal direction
en=Mlongit/N eccentricity intransverse direction
A=(width-2*el)*(depth-2*en)
sigma=N/A

Analysis of construction stages

3 Stability checks back columns complete states

Analysis of construction stages

K12

Ground pressure side span columns ULS2

Forces from analysis

axis		Min N						Foundation sizes				eccentrivcity				ground pressure
		N	M longit	M transv	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
tag	pos															
1-A	0	-56.70	3.50	-7.64	0.11	-0.65	0.80	7	15	3	7875	-64.57	0.15	0.09	99.32	-0.65
1-B	0	-71.27	13.07	-12.57	0.23	-1.04	0.19	7	15	3	7875	-79.14	0.20	0.17	96.78	-0.82
1-C	0	-52.60	-33.92	6.33	-0.45	0.27	0.76	7	15	3	7875	-60.47	0.12	0.60	93.36	-0.65
1-D	0	-46.78	-45.21	11.28	-0.45	0.58	1.04	7	18	3	9450	-56.23	0.23	0.86	106.43	-0.53
1-E	0	-49.04	40.31	-6.96	0.38	-0.24	-0.50	8	18	3	10800	-59.84	0.13	0.70	128.55	-0.47
		Min M longit														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
1-A		-52.70	-14.08	22.00	-0.34	3.63	-0.25	7	15	3	7875	-60.58	0.54	0.24	85.82	-0.71
1-B		-66.48	-43.07	14.18	-0.64	1.27	1.01	7	15	3	7875	-74.36	0.24	0.62	89.66	-0.83
1-C		-41.42	-69.44	4.47	-0.85	0.13	1.81	7	15	3	7875	-49.29	0.10	1.52	81.38	-0.61
1-D		-30.62	-106.86	11.41	-1.02	0.59	2.69	7	18	3	9450	-40.07	0.33	2.87	77.76	-0.52
1-E		-33.78	-112.54	3.21	-0.79	0.06	2.77	8	18	3	10800	-44.58	0.08	2.71	98.71	-0.45
		Min M transv														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
1-A		-52.01	1.00	-12.74	0.05	-1.56	-0.14	7	15	3	7875	-59.89	0.29	0.02	95.96	-0.62
1-B		-66.36	3.14	-16.34	0.08	-1.45	-0.18	7	15	3	7875	-74.23	0.28	0.05	96.00	-0.77
1-C		-36.76	26.59	-18.76	0.37	-1.30	-0.80	7	15	3	7875	-44.64	0.51	0.65	81.99	-0.54
1-D		-38.85	16.53	-9.78	0.18	-0.46	-0.45	7	18	3	9450	-48.30	0.23	0.37	112.84	-0.43
1-E		-30.27	37.97	-11.65	0.31	-0.51	-0.82	8	18	3	10800	-41.07	0.32	0.98	117.96	-0.35

axis		Max N						Foundation sizes				eccentrivcity				ground pressure
		N	M longit	M transv	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
1-A		-48.72	-2.88	20.89	-0.05	3.39	0.32	7	15	3	7875	-56.60	0.55	0.07	87.73	-0.65
1-B		-61.79	-9.73	14.42	-0.13	1.27	0.49	7	15	3	7875	-69.66	0.26	0.16	95.07	-0.73
1-C		-31.72	12.54	-16.62	0.15	-1.16	-0.26	7	15	3	7875	-39.60	0.51	0.34	85.75	-0.46
1-D		-20.92	19.19	-5.96	0.18	-0.23	-0.39	7	18	3	9450	-30.37	0.22	0.67	109.30	-0.28
1-E		-22.37	-23.97	2.00	-0.20	-0.02	0.55	8	18	3	10800	-33.17	0.06	0.77	129.61	-0.26
		Max M longit														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
1-A		-51.93	17.10	-8.51	0.40	-0.83	0.28	7	15	3	7875	-59.80	0.18	0.30	95.50	-0.63
1-B		-65.79	50.53	-12.86	0.76	-1.09	-1.08	7	15	3	7875	-73.67	0.22	0.73	88.86	-0.83
1-C		-44.48	80.98	-14.66	1.01	-0.98	-1.95	7	15	3	7875	-52.35	0.34	1.66	73.92	-0.71
1-D		-37.05	124.47	-7.21	1.20	-0.31	-2.92	7	18	3	9450	-46.50	0.17	2.86	81.60	-0.57
1-E		-38.88	124.22	-8.17	0.91	-0.32	-2.68	8	18	3	10800	-49.68	0.18	2.66	96.74	-0.51
		Max M transv														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
1-A		-53.93	2.82	26.65	0.05	4.41	0.35	7	15	3	7875	-61.81	0.65	0.06	84.93	-0.73
1-B		-66.81	-4.62	18.33	-0.10	1.70	0.56	7	15	3	7875	-74.68	0.31	0.08	94.51	-0.79
1-C		-48.16	-33.60	8.53	-0.46	0.43	1.14	7	15	3	7875	-56.03	0.18	0.66	90.95	-0.62
1-D		-30.34	-64.24	14.25	-0.66	0.76	1.88	7	18	3	9450	-39.79	0.42	1.76	89.37	-0.45
1-E		-43.48	-59.07	7.01	-0.49	0.26	1.13	8	18	3	10800	-54.28	0.14	1.15	121.08	-0.45

Used formulaes:

N=Nanalysis+DN (N from analysis+weight from foundation)
el=Mtransv/N eccentricity in longitudinal direction
en=Mlongit/N eccentricity intransverse direction
A=(width-2*el)*(depth-2*en)
sigma=N/A

K12
Ground pressure side span columns ULS3

Mn sterk akse Ml svak akse

		Min N						Foundation sizes				eccentrivcity				ground pressure
		N	M longit	M transv	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
tag	**pos**															
1-A	**0**	-52.24	1.57	-9.02	0.09	-0.88	-0.12	7	15	3	7875	-60.1	0.19	0.03	98.75	-0.61
1-B	**0**	-66.18	31.80	-13.85	0.59	-1.16	-1.11	7	15	3	7875	-74.1	0.23	0.47	91.78	-0.81
1-C	**0**	-51.11	-58.83	9.51	-0.81	0.49	1.56	7	15	3	7875	-59.0	0.19	1.08	85.14	-0.69
1-D	**0**	-46.17	-44.03	13.07	-0.46	0.65	1.12	7	18	3	9450	-55.6	0.27	0.85	105.27	-0.53
1-E	**0**	-43.16	-49.94	-6.91	-0.40	-0.28	1.06	8	18	3	10800	-54.0	0.14	0.98	123.63	-0.44
		Min M longit														
		N	**M longit**	**M transv**	**T**	**V longit**	**V transv**									
		MN	**MNm**	**MNm**	**MNm**	**MN**	**MN**									
1-A	**0**	-50.28	-8.05	22.24	-0.25	3.62	0.26	7	15	3	7875	-58.2	0.57	0.15	86.15	-0.68
1-B	**0**	-63.80	-60.19	17.87	-1.06	1.59	1.95	7	15	3	7875	-71.7	0.32	0.92	83.79	-0.86
1-C	**0**	-40.14	-125.62	7.40	-1.69	0.30	3.45	7	15	3	7875	-48.0	0.17	2.83	62.12	-0.77
1-D	**0**	-33.55	-215.20	13.83	-2.16	0.72	5.56	7	18	3	9450	-43.0	0.37	5.39	45.14	-0.95
1-E	**0**	-34.04	-226.91	4.79	-1.82	0.13	4.81	8	18	3	10800	-44.8	0.12	5.38	56.20	-0.80
		Min M transv														
		N	**M longit**	**M transv**	**T**	**V longit**	**V transv**									
		MN	**MNm**	**MNm**	**MNm**	**MN**	**MN**									
1-A	**0**	-50.55	0.84	-13.46	0.12	-1.56	0.47	7	15	3	7875	-58.4	0.31	0.04	95.19	-0.61
1-B	**0**	-64.33	28.28	-16.61	0.53	-1.40	-0.82	7	15	3	7875	-72.2	0.29	0.43	90.88	-0.79
1-C	**0**	-39.85	58.41	-18.43	0.83	-1.23	-1.52	7	15	3	7875	-47.7	0.46	1.32	75.08	-0.64
1-D	**0**	-37.37	108.29	-9.98	1.14	-0.45	-2.72	7	18	3	9450	-46.8	0.24	2.49	84.88	-0.55
1-E	**0**	-34.15	143.31	-12.26	1.20	-0.55	-2.96	8	18	3	10800	-45.0	0.31	3.39	82.89	-0.54

		Max N						Foundation sizes					eccentrivcity			ground pressure
		N	M longit	M transv	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
1-A	**0**	-49.06	-0.99	22.64	0.04	3.69	0.66	7	15	3	7875	-56.9	0.59	0.05	86.64	-0.66
1-B	**0**	-61.93	10.86	15.21	0.21	1.34	-0.01	7	15	3	7875	-69.8	0.28	0.16	94.72	-0.74
1-C	**0**	-33.67	-13.79	-15.23	-0.21	-1.06	0.30	7	15	3	7875	-41.5	0.44	0.35	87.38	-0.48
1-D	**0**	-25.28	-24.68	-5.03	-0.26	-0.18	0.60	7	18	3	9450	-34.7	0.16	0.76	110.05	-0.32
1-E	**0**	-27.95	51.96	1.45	0.47	-0.03	-0.98	8	18	3	10800	-38.8	0.04	1.42	120.13	-0.32
		Max M longit														
		N	**M longit**	**M transv**	**T**	**V longit**	**V transv**									
		MN	**MNm**	**MNm**	**MNm**	**MN**	**MN**									
1-A	**0**	-50.16587	7.001957	-10.75551	0.319502	-1.172741	0.493153	7	15	3	7875	-58.0	0.25	0.15	95.72	-0.61
1-B	**0**	-63.74695	72.22095	-13.33487	1.27252	-1.126574	-2.220534	7	15	3	7875	-71.6	0.23	1.10	83.61	-0.86
1-C	**0**	-44.21021	151.626	-15.30264	2.080734	-1.029837	-4.179178	7	15	3	7875	-52.1	0.35	3.15	54.73	-0.95
1-D	**0**	-36.79052	261.9239	-7.713299	2.683288	-0.342927	-6.752432	7	18	3	9450	-46.2	0.19	6.10	38.37	-1.20
1-E	**0**	-37.55429	276.6026	-9.318872	2.276451	-0.38286	-5.76062	8	18	3	10800	-48.4	0.22	6.08	44.23	-1.09
		Max M transv														
		N	**M longit**	**M transv**	**T**	**V longit**	**V transv**									
		MN	**MNm**	**MNm**	**MNm**	**MN**	**MN**									
1-A	**0**	-50.66	-0.99	27.54	-0.12	4.41	-0.41	7	15	3	7875	-58.5	0.70	0.04	83.68	-0.70
1-B	**0**	-63.81	-27.85	18.98	-0.53	1.68	0.77	7	15	3	7875	-71.7	0.33	0.42	89.63	-0.80
1-C	**0**	-50.93	-24.47	10.07	-0.35	0.51	0.65	7	15	3	7875	-58.8	0.20	0.45	93.14	-0.63
1-D	**0**	-34.47	-113.92	14.43	-1.16	0.74	2.95	7	18	3	9450	-43.9	0.38	2.80	77.45	-0.57
1-E	**0**	-39.56	-126.57	6.29	-1.01	0.22	2.67	8	18	3	10800	-50.4	0.14	2.67	97.75	-0.52

Used formulaes:

N=Nanalysis+DN (N from analysis+weight from foundation)
el=Mtransv/N eccentricity in longitudinal direction
en=Mlongit/N eccentricity intransverse direction
A=(width-2*el)*(depth-2*en)
sigma=N/A

K12
Ground pressure side spans columns PLS ship collision

Column 1-A

		Forces from ship collisionanalysis						Forces from permanent loads			sum bending moments		Foundation sizes					eccentrivcity			ground pressure
		Axial	Shear force		Bending moment	Bending moment		permanent load			Bending moment	Bending moment	Width	Depth	Height	DN	N	el	en	A	sigma
		force [MN]	longitudinal [MN	orce transver	roll [MNm]	pitch [MNm]	onal moment [M	N	M longit	M transv	roll [MNm]	pitch [MNm]	m	m	m	KN	MN	m	m	m2	Mpa
Max	Axial force [MN]	8.67	1.292	2.363	67.23	3.481	4.296	-41.473	0	5.918	74.32	13.28	7	15	3	7875	-40.68	0.33	1.83	72.02	-0.56
	Shear force longitudinal [MN]	4.42	3.631	4.8014	86.73	6.711	4.65924	-41.473	0	5.918	101.13	23.52	7	15	3	7875	-44.93	0.52	2.25	62.49	-0.72
	Shear force transverse [MN]	4.51	1.257	12.49	40.71	3.287	3.6224	-41.473	0	5.918	78.18	12.98	7	15	3	7875	-44.84	0.29	1.74	73.93	-0.61
	Bending moment roll [MNm]	3.99	2.364	-3.4416	121.95	4.361	4.319	-41.473	0	5.918	132.27	17.37	7	15	3	7875	-45.36	0.38	2.92	57.15	-0.79
	Bending moment pitch [MNm]	3.36	3.631	3.573	108.05	8.295	4.111	-41.473	0	5.918	118.77	25.11	7	15	3	7875	-45.99	0.55	2.58	58.11	-0.79
	Torsional moment [MNm]	4.71	1.227	5.283	118.52	2.164	9.5776	-41.473	0	5.918	134.37	11.76	7	15	3	7875	-44.64	0.26	3.01	58.12	-0.77
Min	Axial force [MN]	-9.16	-1.3354	-10.651	-27.858	-3.593	-5.59	-41.473	0	5.918	59.81	13.52	7	15	3	7875	-58.51	0.23	1.02	84.70	-0.69
	Shear force longitudinal [MN]	-6.69	-4.334	-10.4499	-22.1842	-8.117	-5.2041	-41.473	0	5.918	53.53	27.04	7	15	3	7875	-56.04	0.48	0.96	78.99	-0.71
	Shear force transverse [MN]	-3.83	-2.78	-15.87	25.5834	-4.6338	-4.4794	-41.473	0	5.918	73.19	18.89	7	15	3	7875	-53.18	0.36	1.38	77.03	-0.69
	Bending moment roll [MNm]	-3.5	-1.3152	-0.554	-107.73	-4.6928	-4.36976	-41.473	0	5.918	109.39	14.56	7	15	3	7875	-52.85	0.28	2.07	70.04	-0.75
	Bending moment pitch [MNm]	-4.7	-3.733	-8.497	-14.82	-8.54	-4.6364	-41.473	0	5.918	40.31	25.66	7	15	3	7875	-54.05	0.47	0.75	81.73	-0.66
	Torsional moment [MNm]	-4.19	-1.8222	-7.78	-62.38	-4.8322	-9.7394	-41.473	0	5.918	85.72	16.22	7	15	3	7875	-53.54	0.30	1.60	75.44	-0.71

Column 1-B

		Forces from ship collisionanalysis						Forces from permanent loads			sum bending moments		Foundation sizes					eccentrivcity			ground pressure
		Axial	Shear force		Bending moment	Bending moment		permanent load			Bending moment	Bending moment	Width	Depth	Height	DN	N	el	en	A	sigma
		force [MN]	longitudinal [MN	orce transver	roll [MNm]	pitch [MNm]	onal moment [M	N	M longit	M transv	roll [MNm]	pitch [MNm]	m	m	m	KN	MN	m	m	m2	Mpa
Max	Axial force [MN]	2.6	1.21751	8.708	87.885	4.1571	4.5842	-52.582	0.001	1.156	114.01	8.97	7	15	3	7875	-57.86	0.15	1.97	73.98	-0.78
	Shear force longitudinal [MN]	1.52	1.93981	8.2407	57.754	8.2236	4.6755	-52.582	0.001	1.156	82.48	15.20	7	15	3	7875	-58.94	0.26	1.40	79.12	-0.74
	Shear force transverse [MN]	1.48	0.36061	15.61241	27.245	2.4842	3.717	-52.582	0.001	1.156	74.08	4.72	7	15	3	7875	-58.98	0.08	1.26	85.41	-0.69
	Bending moment roll [MNm]	1.46	0.45613	0.852	146.4	3.7331	4.7748	-52.582	0.001	1.156	148.96	6.26	7	15	3	7875	-59.00	0.11	2.52	67.54	-0.87
	Bending moment pitch [MNm]	1.16	1.80481	5.3761	55.965	10.4982	4.6755	-52.582	0.001	1.156	72.09	17.07	7	15	3	7875	-59.30	0.29	1.22	80.74	-0.73
	Torsional moment [MNm]	0.84	1.53081	4.4384	79.723	6.2662	8.9434	-52.582	0.001	1.156	93.04	12.01	7	15	3	7875	-59.62	0.20	1.56	78.36	-0.76
Min	Axial force [MN]	-3.5	-0.71296	-11.3405	-34.083	-5.2224	-5.619	-52.582	0.001	1.156	68.11	8.52	7	15	3	7875	-63.96	0.13	1.06	86.66	-0.74
	Shear force longitudinal [MN]	-1.81	-1.72819	-8.268	-41.85	-7.8998	-4.958	-52.582	0.001	1.156	66.66	14.24	7	15	3	7875	-62.27	0.23	1.07	84.13	-0.74
	Shear force transverse [MN]	-2.22	-0.93707	-16.5	-18.05	-5.2224	-4.0359	-52.582	0.001	1.156	67.55	9.19	7	15	3	7875	-62.68	0.15	1.08	86.14	-0.73
	Bending moment roll [MNm]	-2.16	-0.44566	-1.6502	-148.753	-4.289	-5.04848	-52.582	0.001	1.156	153.70	6.78	7	15	3	7875	-62.62	0.11	2.45	68.45	-0.91
	Bending moment pitch [MNm]	-1.65	-1.72019	-5.871721	-54.34	-8.3538	-4.036	-52.582	0.001	1.156	71.96	14.67	7	15	3	7875	-62.11	0.24	1.16	82.79	-0.75
	Torsional moment [MNm]	-1.48	-0.75447	-9.1385	-82.815	-2.6451	-9.5506	-52.582	0.001	1.156	110.23	6.06	7	15	3	7875	-61.94	0.10	1.78	77.84	-0.80

Column 1-C

		Forces from ship collisionanalysis						Forces from permanent loads			sum bending moments		Foundation sizes					eccentrivcity			ground pressure
		Axial	Shear force		Bending moment	Bending moment		permanent load			Bending moment	Bending moment	Width	Depth	Height	DN	N	el	en	A	sigma
		force [MN]	longitudinal [MN	orce transver	roll [MNm]	pitch [MNm]	onal moment [M	N	M longit	M transv	roll [MNm]	pitch [MNm]	m	m	m	KN	MN	m	m	m2	Mpa
Max	Axial force [MN]	4.79	0.34642	4.7585	61.236	2.9966	2.454	-34.625	0.003	-3.639	75.51	7.67	7	15	3	7875	-37.71	0.20	2.00	72.49	-0.52
	Shear force longitudinal [MN]	2.53	2.3732	11.17014	65.097	15.264	3.4432	-34.625	0.003	-3.639	98.61	26.02	7	15	3	7875	-39.97	0.65	2.47	57.35	-0.70
	Shear force transverse [MN]	1.94	0.6941	11.17014	14.019	4.766	2.4982	-34.625	0.003	-3.639	47.53	10.49	7	15	3	7875	-40.56	0.26	1.17	82.05	-0.49
	Bending moment roll [MNm]	2.36	1.1006	0.793	155.358	11.73	2.5868	-34.625	0.003	-3.639	157.74	18.67	7	15	3	7875	-40.14	0.47	3.93	43.34	-0.93
	Bending moment pitch [MNm]	1.91	2.1391	11.17014	65.097	19.274	3.2008	-34.625	0.003	-3.639	98.61	29.33	7	15	3	7875	-40.59	0.72	2.43	56.33	-0.72
	Torsional moment [MNm]	2.49	1.3706	6.3074	83.376	5.527	5.2008	-34.625	0.003	-3.639	102.30	13.28	7	15	3	7875	-40.01	0.33	2.56	62.64	-0.64
Min	Axial force [MN]	-5.06	-0.6984	-5.187	-90.678	-3.275	-2.5378	-34.625	0.003	-3.639	106.24	9.01	7	15	3	7875	-47.56	0.19	2.23	69.74	-0.68
	Shear force longitudinal [MN]	-1.86	-2.3958	-5.718	-54.138	-16.506	-3.2663	-34.625	0.003	-3.639	71.30	27.33	7	15	3	7875	-44.36	0.62	1.61	67.98	-0.65
	Shear force transverse [MN]	-2.11	-0.9858	-10.8999	-17.066	-6.743	-4.4533	-34.625	0.003	-3.639	49.77	13.34	7	15	3	7875	-44.61	0.30	1.12	81.74	-0.55
	Bending moment roll [MNm]	-2.4	-0.3671	0.9981	-184.573	-1.829	-3.7883	-34.625	0.003	-3.639	187.57	6.57	7	15	3	7875	-44.90	0.15	4.18	44.57	-1.01
	Bending moment pitch [MNm]	-2.89	-2.2418	-8.2579	-57.705	-19.846	-2.4403	-34.625	0.003	-3.639	82.48	30.21	7	15	3	7875	-45.39	0.67	1.82	64.43	-0.70
	Torsional moment [MNm]	-2.4	-0.6432	-7.081	-116.573	-3.918	-6.4573	-34.625	0.003	-3.639	137.82	9.49	7	15	3	7875	-44.90	0.21	3.07	58.28	-0.77

Column 1-D

		Forces from ship collisionanalysis						Forces from permanent loads			sum bending moments		Foundation sizes					eccentrivcity			ground pressure
		Axial	Shear force		Bending moment	Bending moment		permanent load			Bending moment	Bending moment	Width	Depth	Height	DN	N	el	en	A	sigma
		force [MN]	longitudinal [MN	orce transver	roll [MNm]	pitch [MNm]	onal moment [M	N	M longit	M transv	roll [MNm]	pitch [MNm]	m	m	m	KN	MN	m	m	m2	Mpa
Max	Axial force [MN]	7.92	0.4882	4.8914	49.013	4.664	3.5767	-29.391	0.002	2.179	63.69	8.31	7	18	3	9450	-30.92	0.27	2.06	89.71	-0.34
	Shear force longitudinal [MN]	1.42	1.4465	4.594	46.99	16.908	2.0277	-29.391	0.002	2.179	60.77	23.43	7	18	3	9450	-37.42	0.63	1.62	84.79	-0.44
	Shear force transverse [MN]	2.98	0.3651	10.5965	42.315	4.159	2.2664	-29.391	0.002	2.179	74.11	7.43	7	18	3	9450	-35.86	0.21	2.07	91.32	-0.39
	Bending moment roll [MNm]	1	0.7751	-1.5235	204.106	10.008	2.0114	-29.391	0.002	2.179	208.68	14.51	7	18	3	9450	-37.84	0.38	5.51	43.45	-0.87
	Bending moment pitch [MNm]	2.46	1.4465	4.01	75.183	16.908	1.6117	-29.391	0.002	2.179	87.22	23.43	7	18	3	9450	-36.38	0.64	2.40	75.43	-0.48
	Torsional moment [MNm]	1.87	0.7433	3.8383	87.922	4.088	3.7847	-29.391	0.002	2.179	99.44	8.50	7	18	3	9450	-36.97	0.23	2.69	82.54	-0.45
Min	Axial force [MN]	-8.56	-0.5471	-5.6621	-75.97	-6.276	-3.0841	-29.391	0.002	2.179	92.96	10.10	7	18	3	9450	-47.40	0.21	1.96	92.55	-0.51
	Shear force longitudinal [MN]	-3.45	-1.2535	-4.5342	-100.337	-14.212	-2.876047	-29.391	0.002	2.179	113.94	20.15	7	18	3	9450	-42.29	0.48	2.69	76.26	-0.55
	Shear force transverse [MN]	-1.62	-0.488	-9.9962	-15.1528	-5.304	-2.9041	-29.391	0.002	2.179	45.14	8.95	7	18	3	9450	-40.46	0.22	1.12	103.41	-0.39
	Bending moment roll [MNm]	-1.65	-0.4003	1.282	-204.947	-4.888	-2.747	-29.391	0.002	2.179	208.80	8.27	7	18	3	9450	-40.49	0.20	5.16	50.67	-0.80
	Bending moment pitch [MNm]	-3.45	-1.2535	-4.5342	-100.337	-14.212	-2.0121	-29.391	0.002	2.179	113.94	20.15	7	18	3	9450	-42.29	0.48	2.69	76.26	-0.55
	Torsional moment [MNm]	-1.78	-0.5647	-3.7333	-88.6099	-4.375	-4.1167	-29.391	0.002	2.179	99.81	8.25	7	18	3	9450	-40.62	0.20	2.46	86.29	-0.47

Column 1-E

		Forces from ship collisionanalysis						Forces from permanent loads			sum bending moments		Foundation sizes					eccentrivcity			ground pressure
		Axial	Shear force		Bending moment	Bending moment		permanent load			Bending moment	Bending moment	Width	Depth	Height	DN	N	el	en	A	sigma
		force [MN]	longitudinal [MN	orce transver	roll [MNm]	pitch [MNm]	onal moment [M	N	M longit	M transv	roll [MNm]	pitch [MNm]	m	m	m	KN	MN	m	m	m2	Mpa
Max	Axial force [MN]	6.43	0.48568	2.6333	62.604	5.036	2.6842	-29.359	0.001	-2.371	70.50	8.86	8	18	3	10800	-33.73	0.26	2.09	103.29	-0.33
	Shear force longitudinal [MN]	1.26	0.84854	2.53638	46.337	11.535	2.60708	-29.359	0.001	-2.371	53.95	16.45	8	18	3	10800	-38.90	0.42	1.39	108.93	-0.36
	Shear force transverse [MN]	2.11	0.39581	5.10238	7.725	3.848	3.2484	-29.359	0.001	-2.371	23.03	7.41	8	18	3	10800	-38.05	0.19	0.61	127.78	-0.30
	Bending moment roll [MNm]	3.71	0.32021	-0.505	105.514	4.401	2.4852	-29.359	0.001	-2.371	107.03	7.73	8	18	3	10800	-36.45	0.21	2.94	91.87	-0.40
	Bending moment pitch [MNm]	1.29	0.84854	1.66292	46.337	11.535	2.5924	-29.359	0.001	-2.371	51.33	16.45	8	18	3	10800	-38.87	0.42	1.32	109.87	-0.35
	Torsional moment [MNm]	1.08	0.34108	1.46882	37.9095	3.735	5.22803	-29.359	0.001	-2.371	42.32	7.13	8	18	3	10800	-39.08	0.18	1.08	120.90	-0.32
Min	Axial force [MN]	-5.94	-0.23032	-1.7611	-42.5044	-2.164	-2.8088	-29.359	0.001	-2.371	47.79	5.23	8	18	3	10800	-46.10	0.11	1.04	123.80	-0.37
	Shear force longitudinal [MN]	-3.22	-0.82666	-2.8923	-57.006	-11.575	-2.86388	-29.359	0.001	-2.371	65.68	16.43	8	18	3	10800	-43.38	0.38	1.51	108.43	-0.40
	Shear force transverse [MN]	-2.26	-0.51323	-4.9654	2.2648	-6.41	-3.042	-29.359	0.001	-2.371	17.16	10.32	8	18	3	10800	-42.42	0.24	0.40	129.16	-0.33
	Bending moment roll [MNm]	-1.52	-0.32015	0.01206	-104.3344	-4.872	-2.57111	-29.359	0.001	-2.371	104.37	8.20	8	18	3	10800	-41.68	0.20	2.50	98.82	-0.42
	Bending moment pitch [MNm]	-1.28	-0.82666	-2.5627	-37.839	-11.575	-2.84711	-29.359	0.001	-2.371	45.53	16.43	8	18	3	10800	-41.44	0.40	1.10	113.89	-0.36
	Torsional moment [MNm]	-1.53	-0.28275	-2.81863	-50.946	-4.238	-5.1321	-29.359	0.001	-2.371	59.40	7.46	8	18	3	10800	-41.69	0.18	1.42	115.78	-0.36
																				43.34	-1.01

Used formulaes:

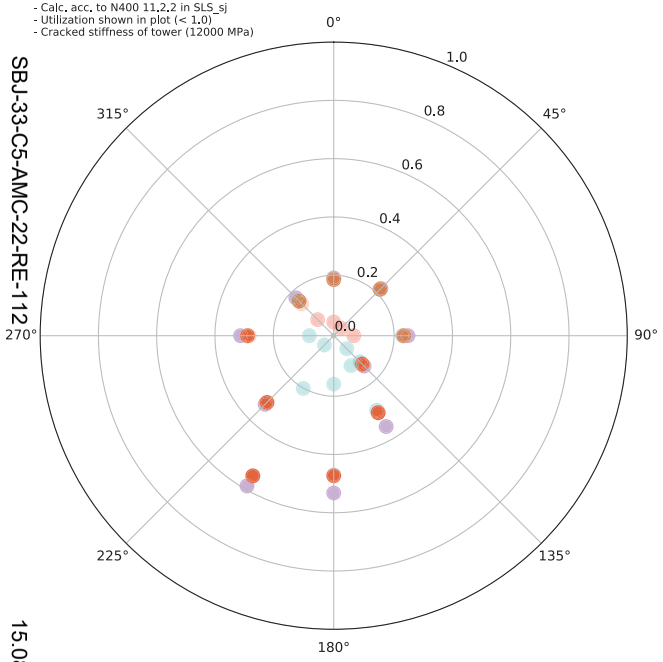
N=Nanalysis+DN (N from analysis+weight from foundation)
el=Mtransv/N eccentricity in longitudinal direction
en=Mlongit/N eccentricity intransverse direction
A=(width-2*el)*(depth-2*en)
sigma=N/A

4 Stability checks tower construction stages

Analysis of construction stages

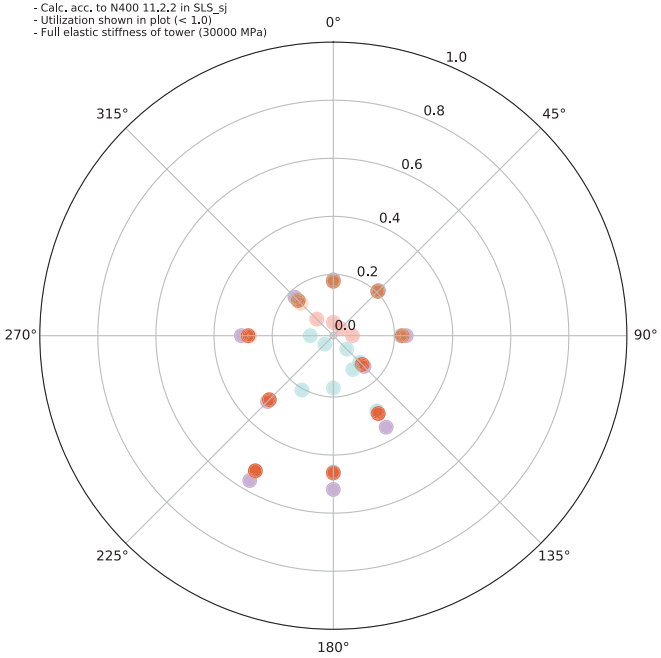
Check of eccentricity
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



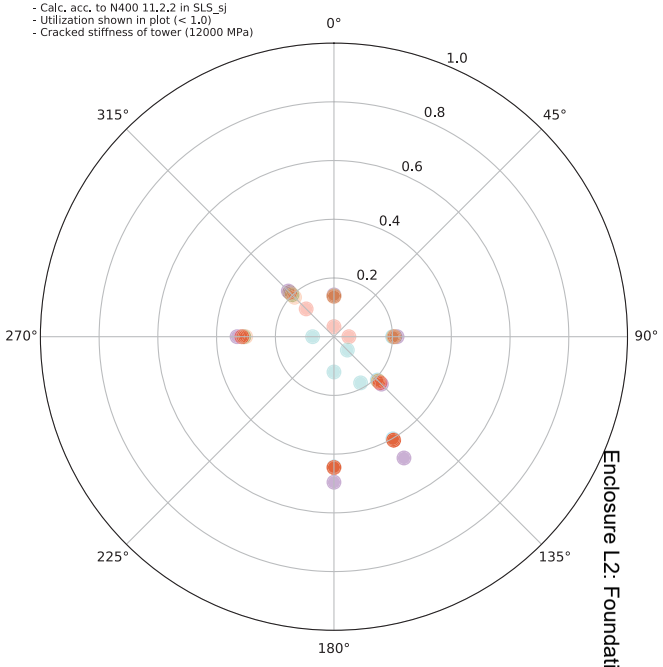
Check of eccentricity
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



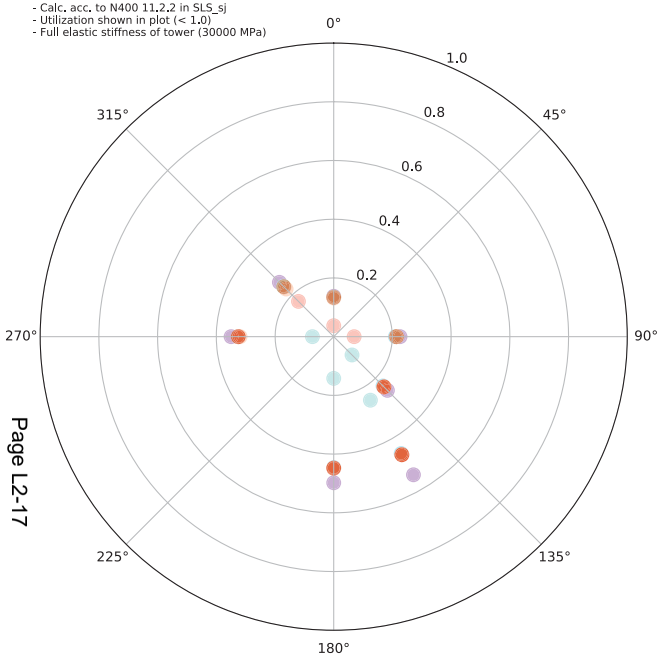
Check of eccentricity
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



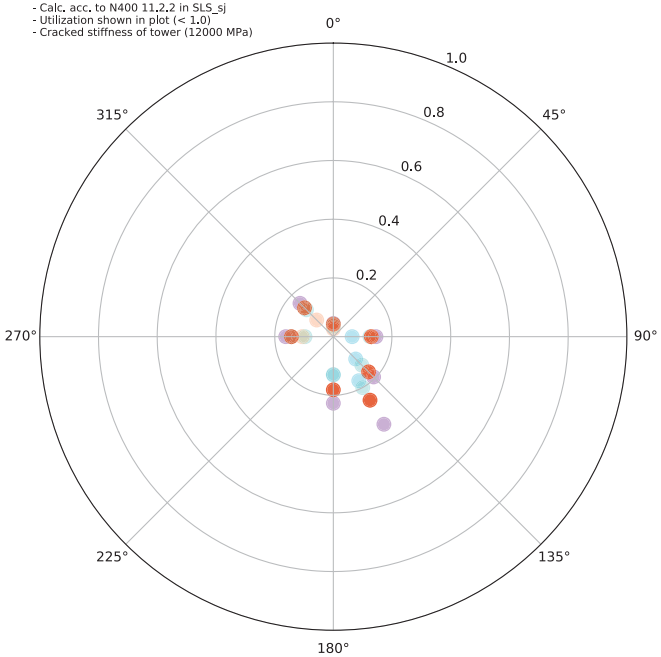
Check of eccentricity
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



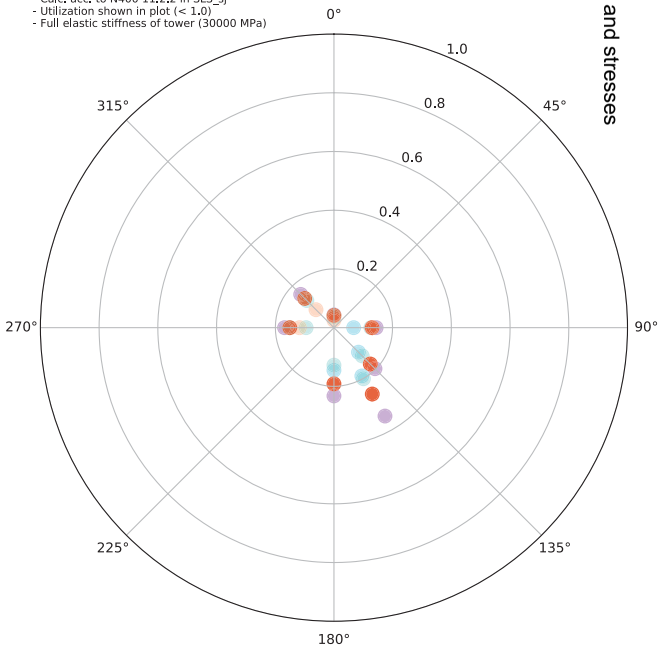
Check of eccentricity
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



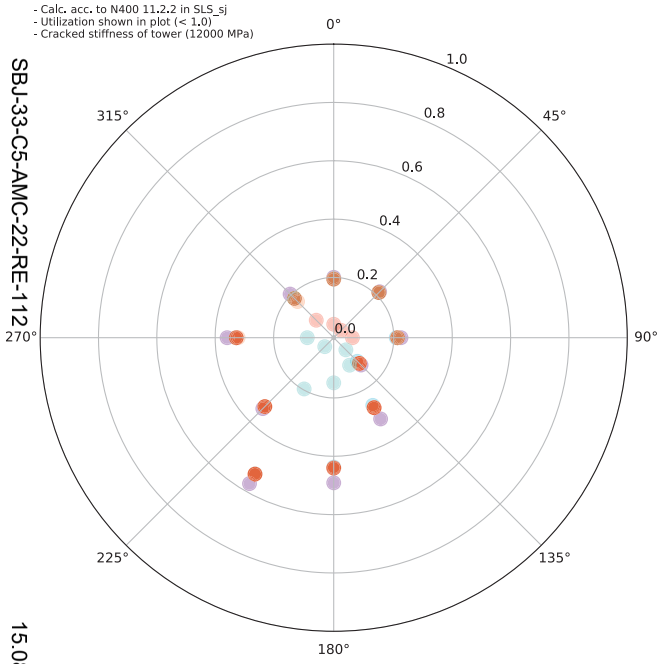
Check of eccentricity
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



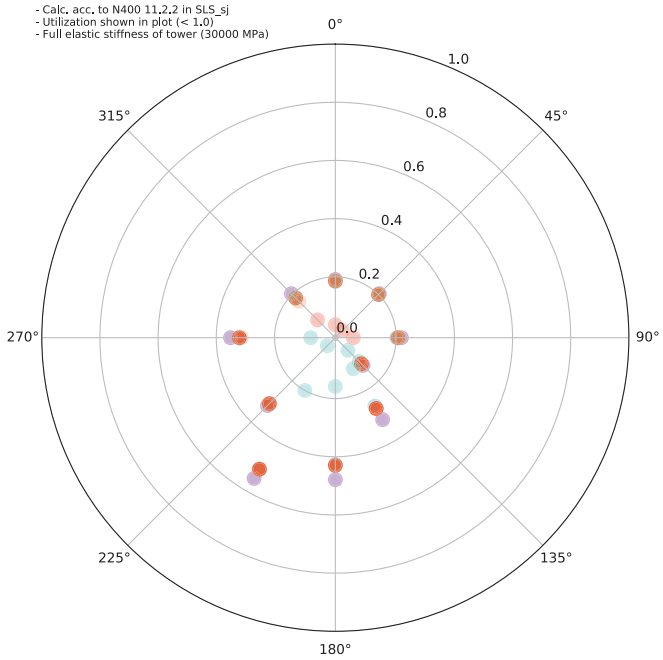
Check of eccentricity
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



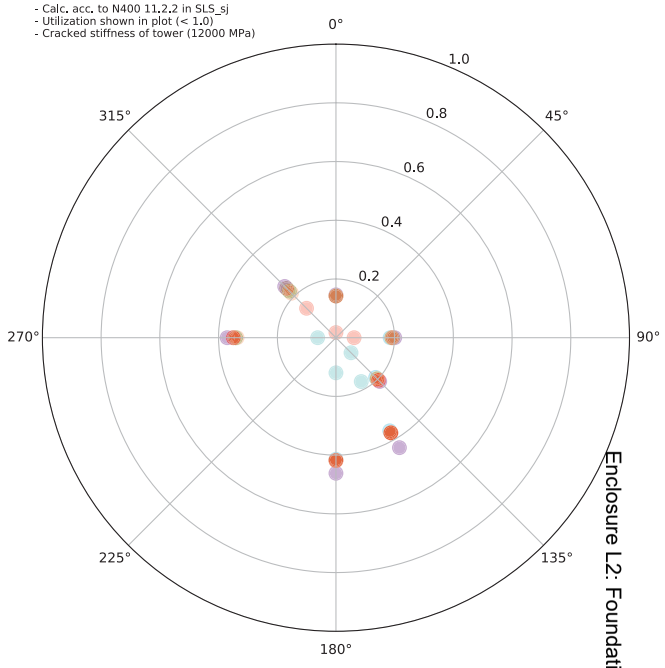
Check of eccentricity
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



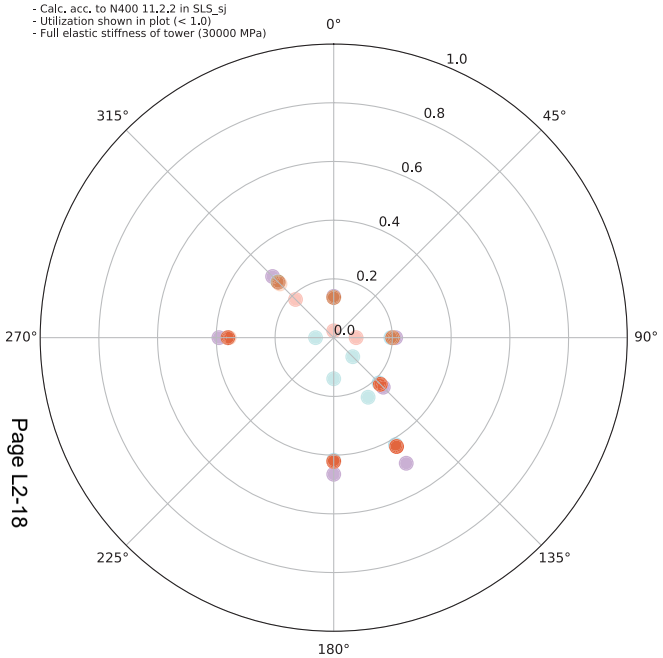
Check of eccentricity
Stage B - Western foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



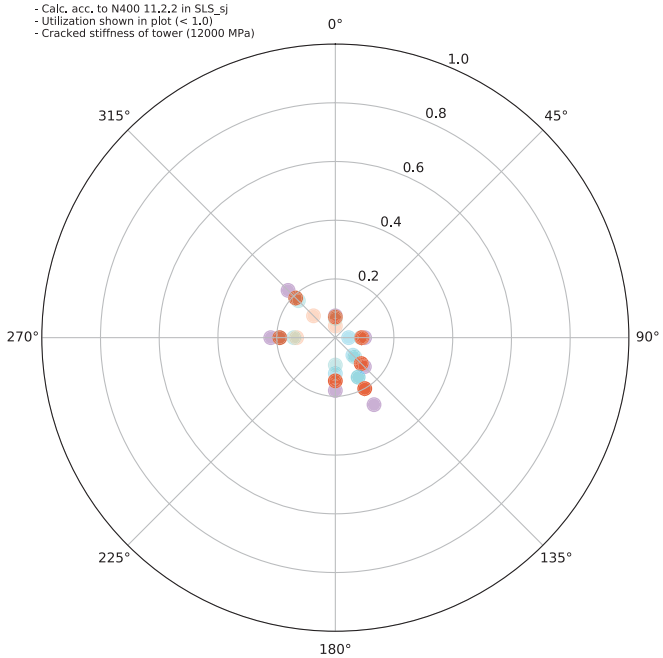
Check of eccentricity
Stage B - Western foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



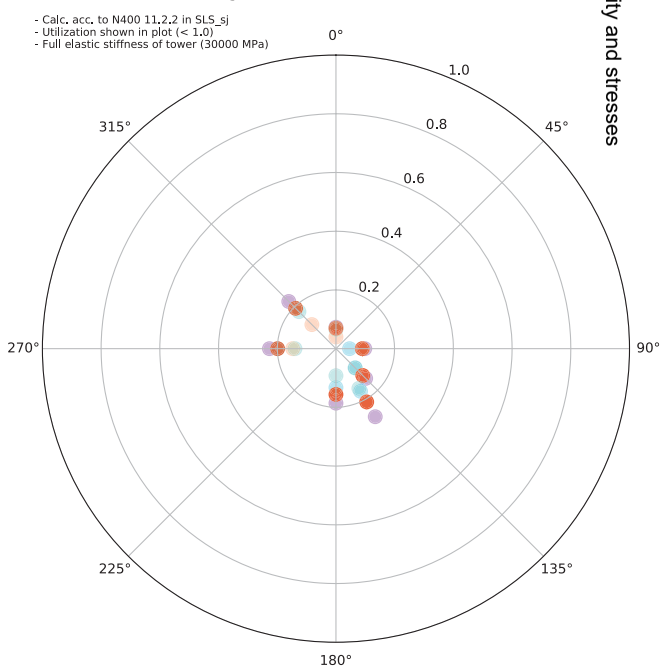
Check of eccentricity
Stage C - Western foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



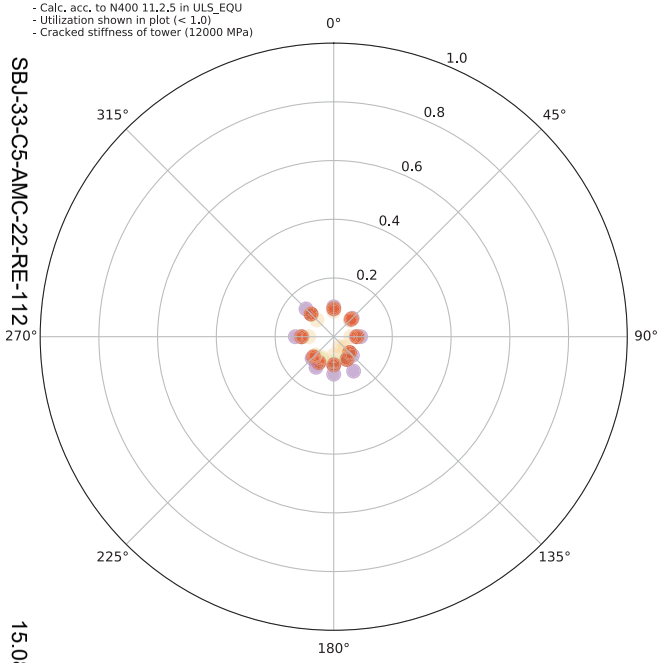
Check of eccentricity
Stage C - Western foundation

- Calc. acc. to N400 11.2.2 in SLS_sj
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



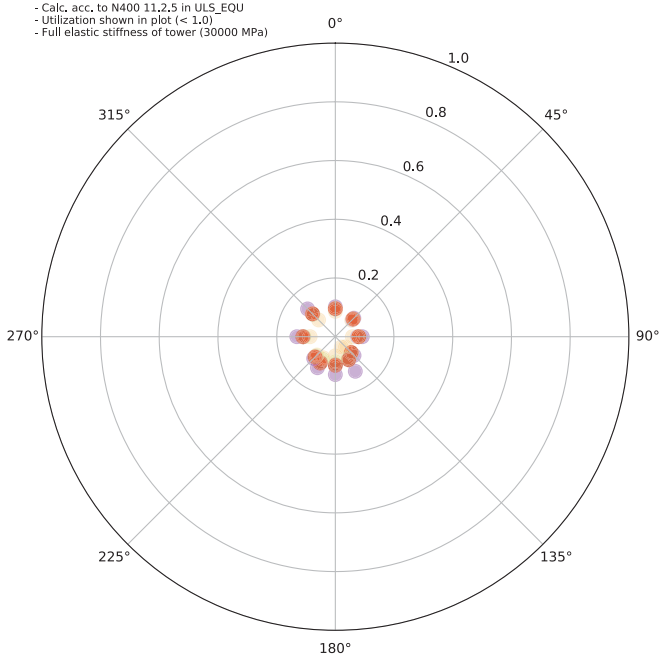
Check of gliding
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



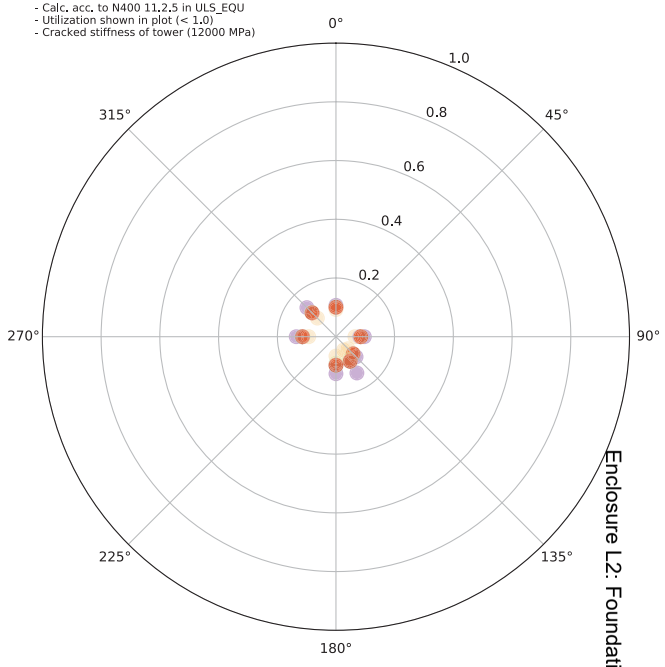
Check of gliding
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



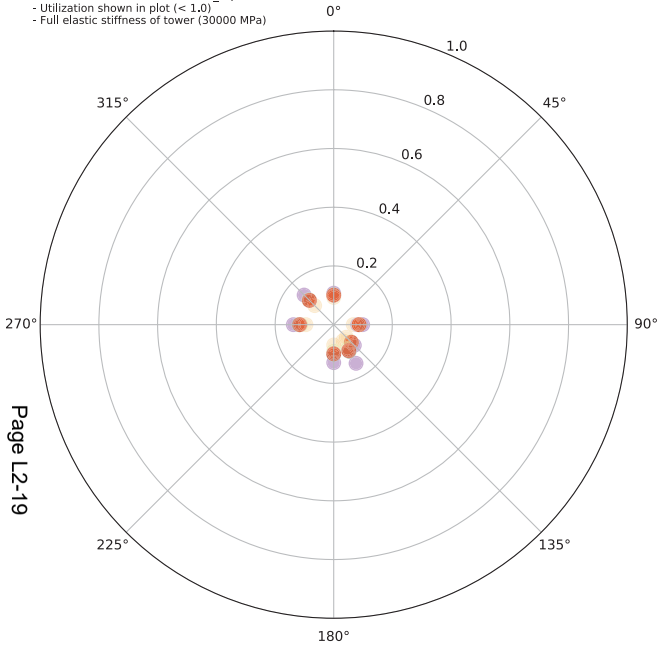
Check of gliding
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



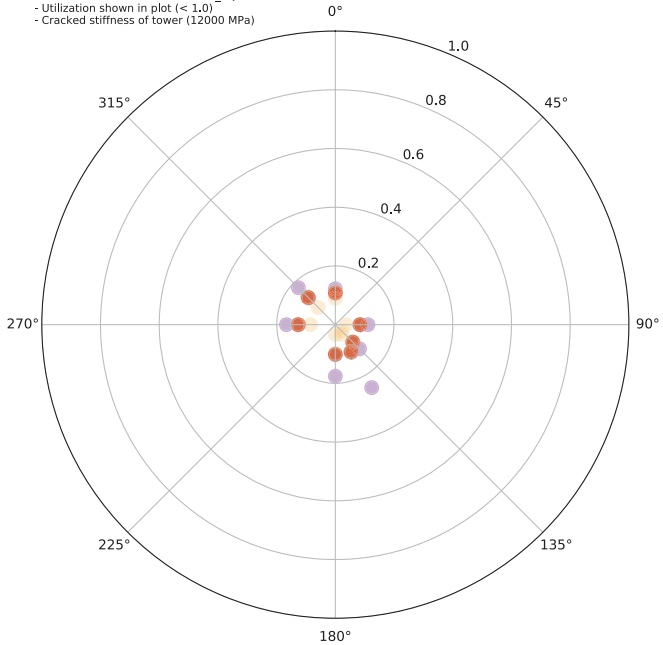
Check of gliding
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



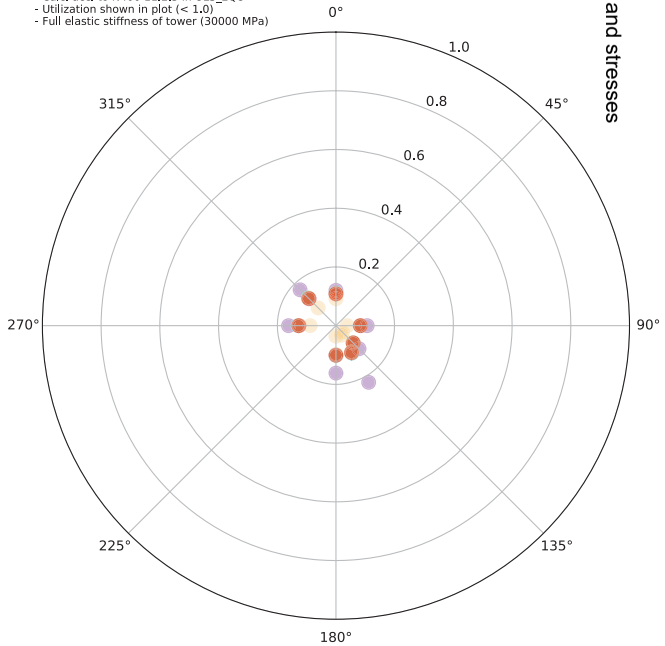
Check of gliding
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



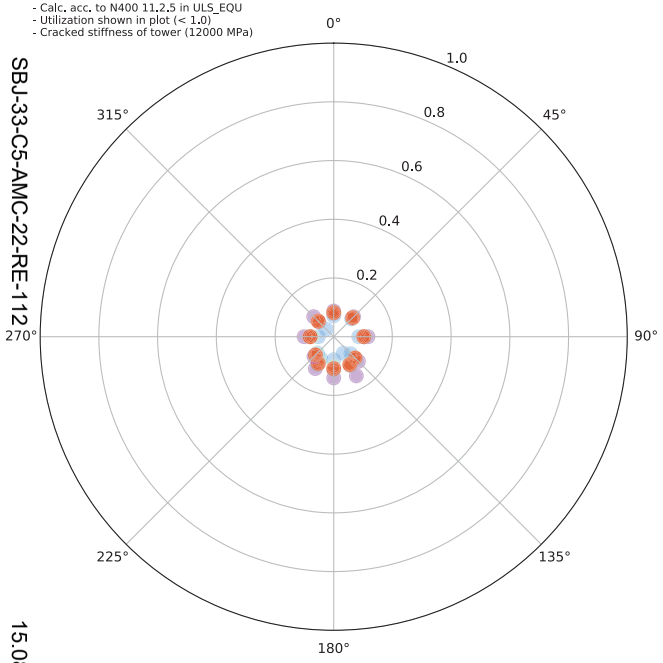
Check of gliding
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



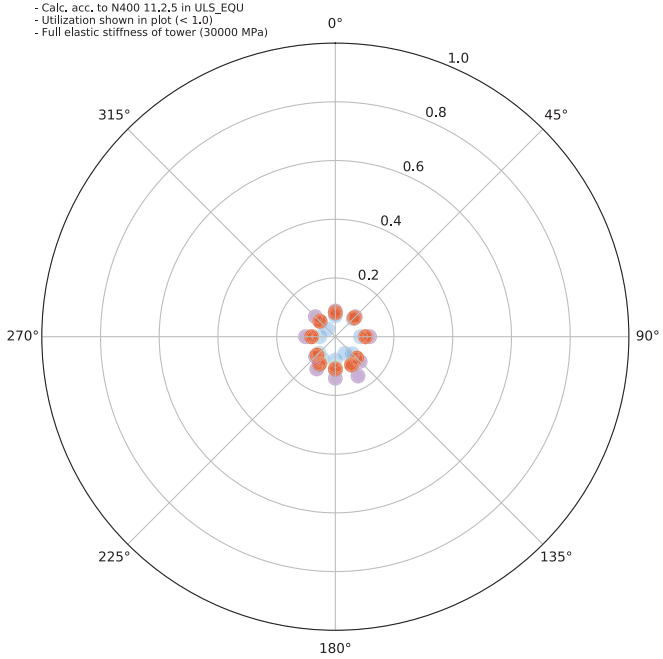
Check of gliding
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



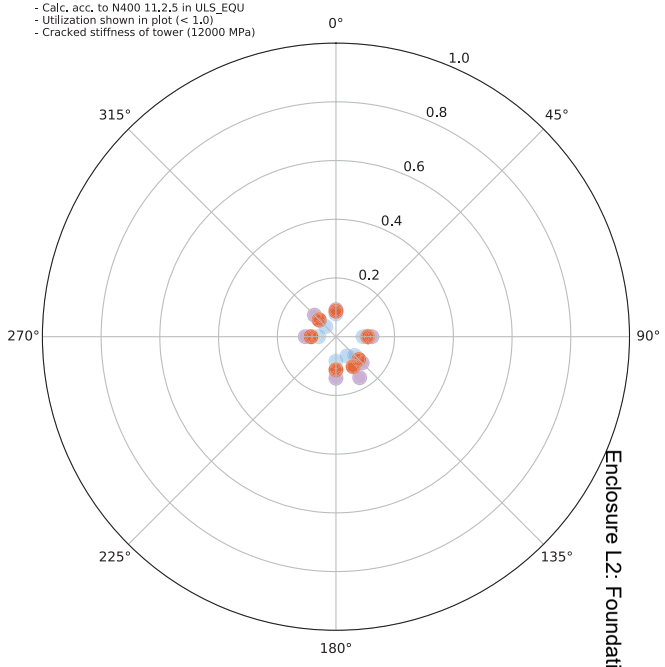
Check of gliding
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



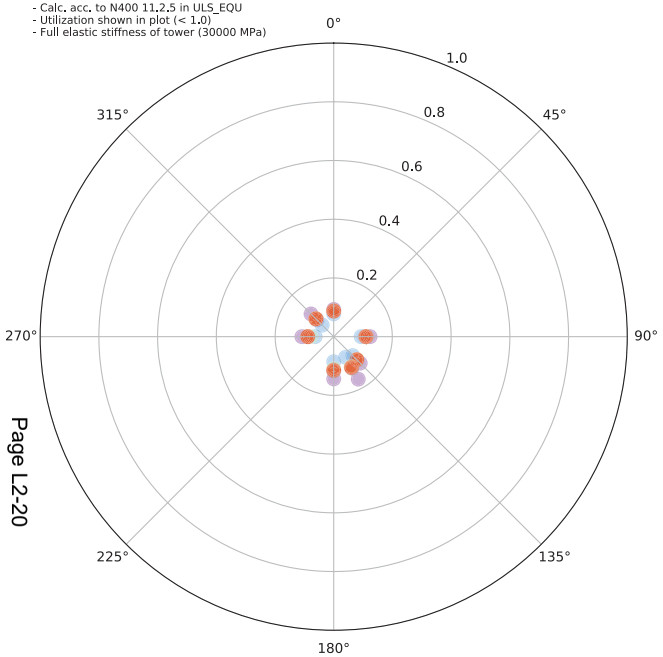
Check of gliding
Stage B - Western foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



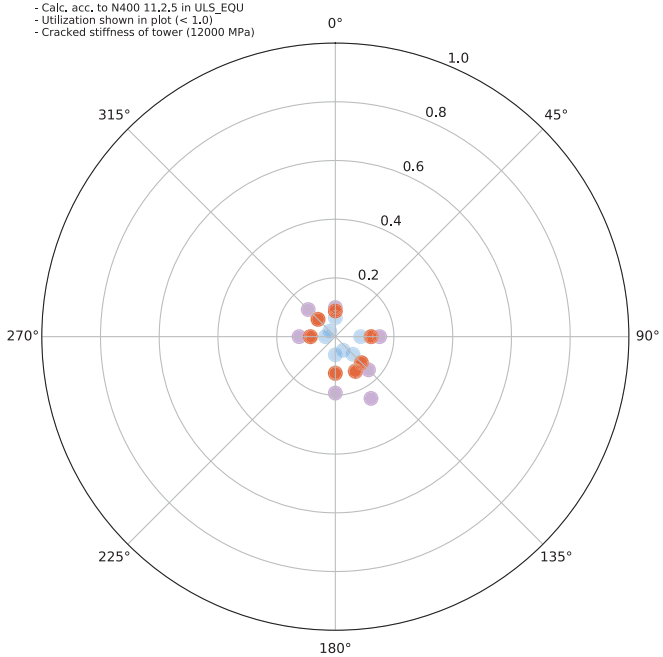
Check of gliding
Stage B - Western foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



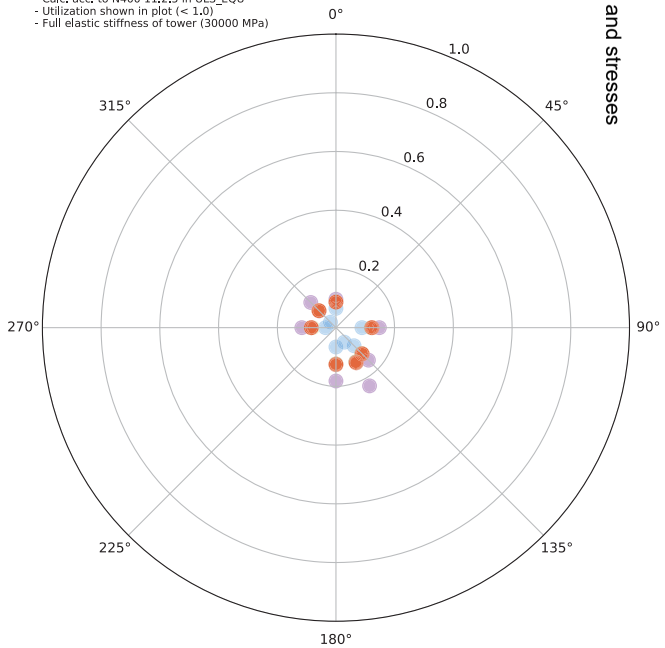
Check of gliding
Stage C - Western foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



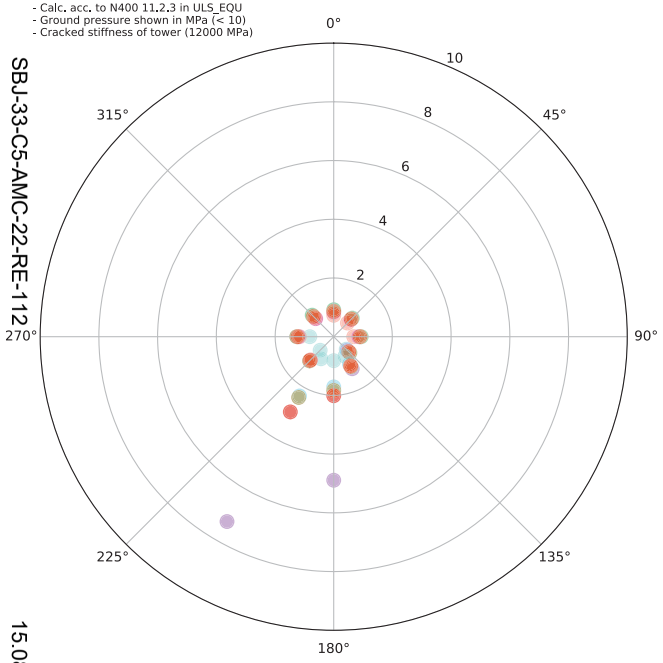
Check of gliding
Stage C - Western foundation

- Calc. acc. to N400 11.2.5 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



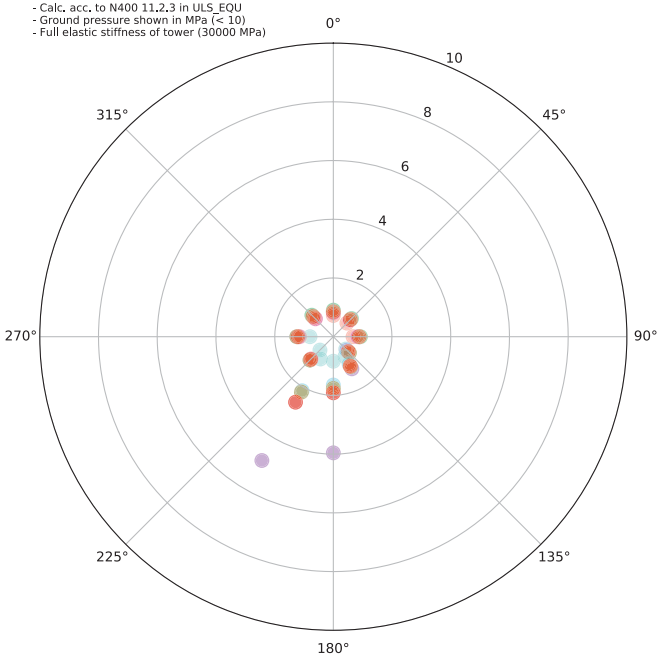
Check of ground pressure
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



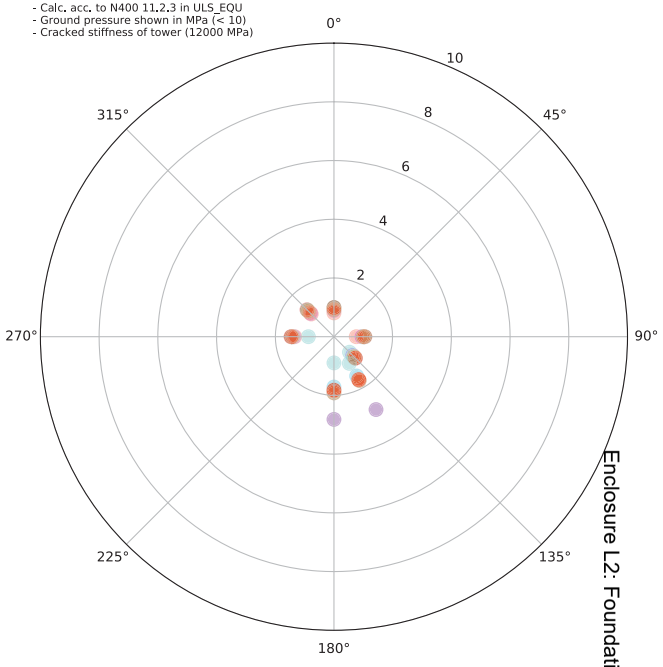
Check of ground pressure
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



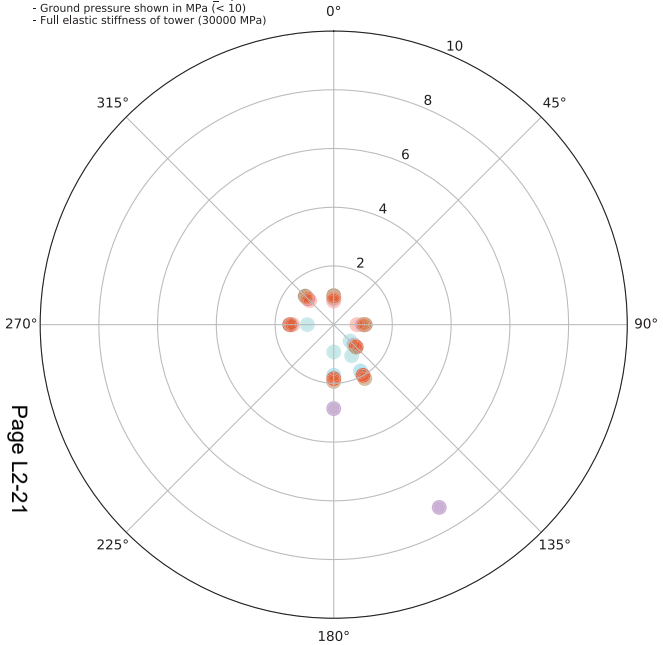
Check of ground pressure
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



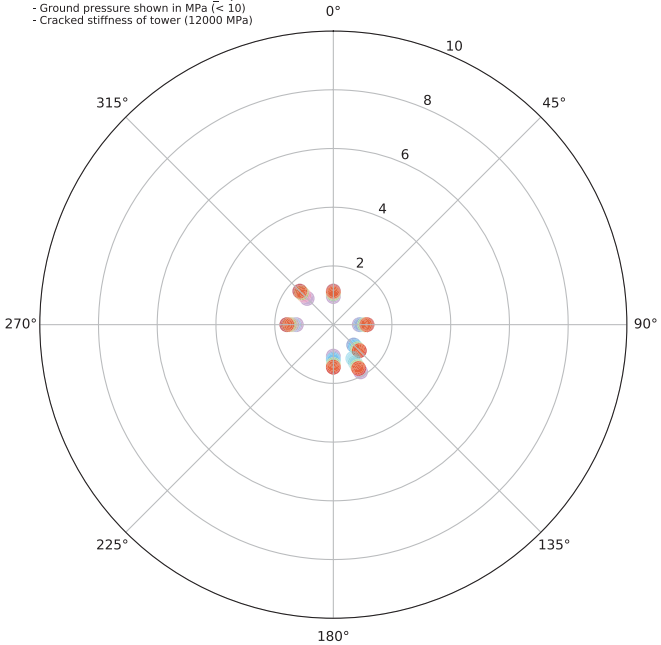
Check of ground pressure
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



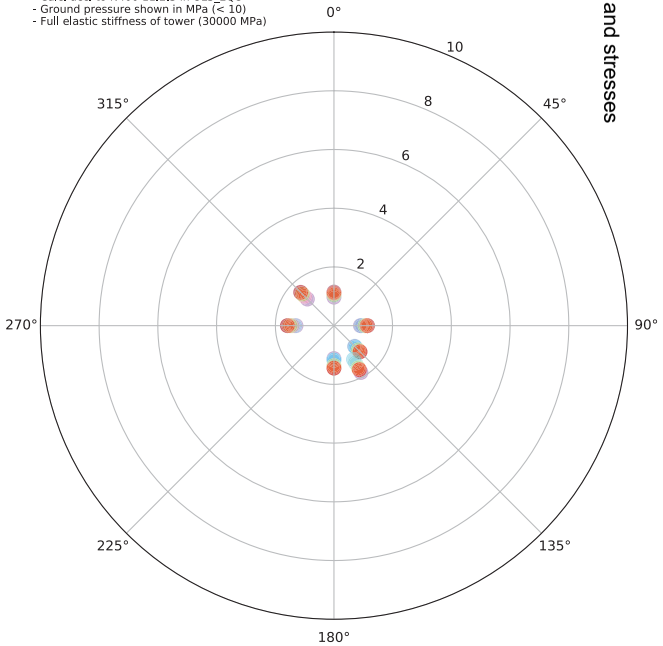
Check of ground pressure
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



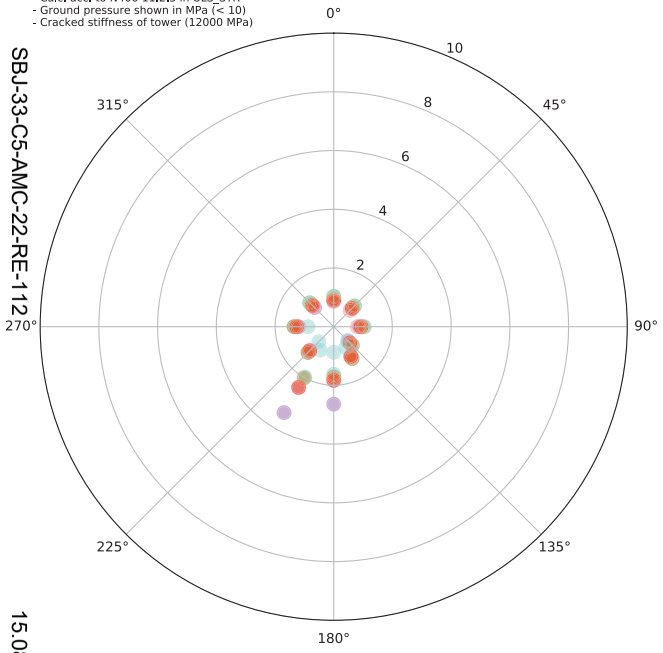
Check of ground pressure
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



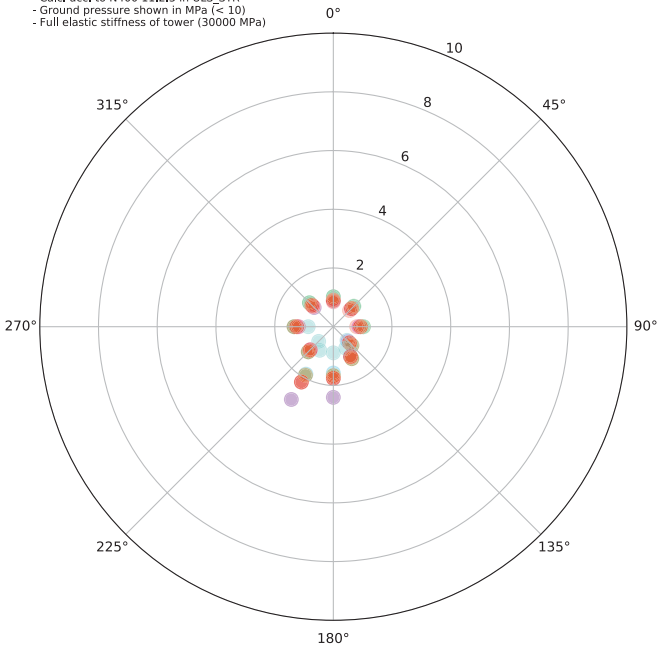
Check of ground pressure
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



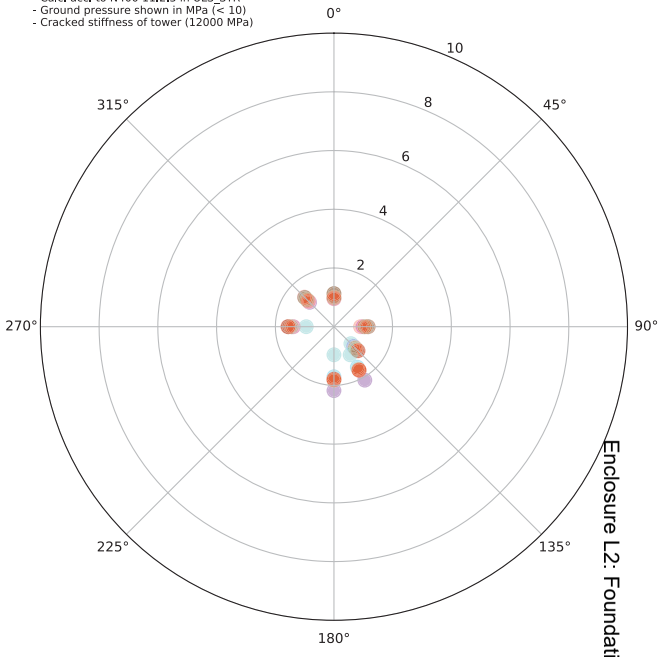
Check of ground pressure
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



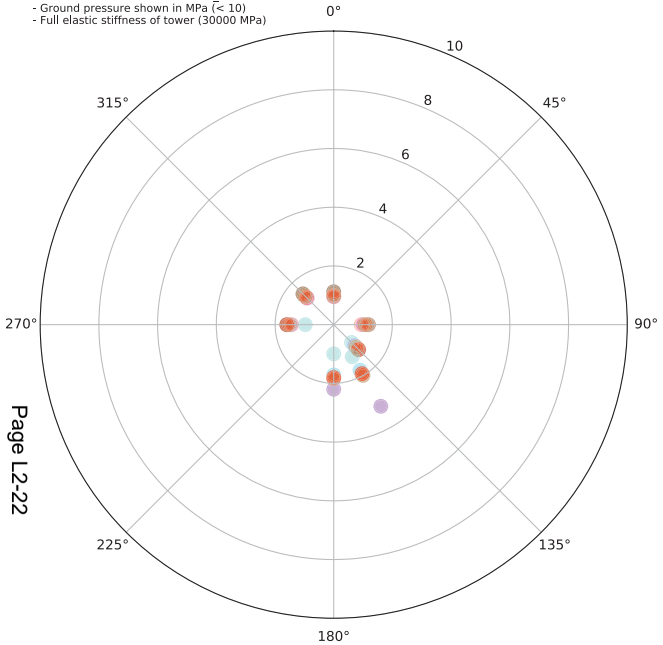
Check of ground pressure
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



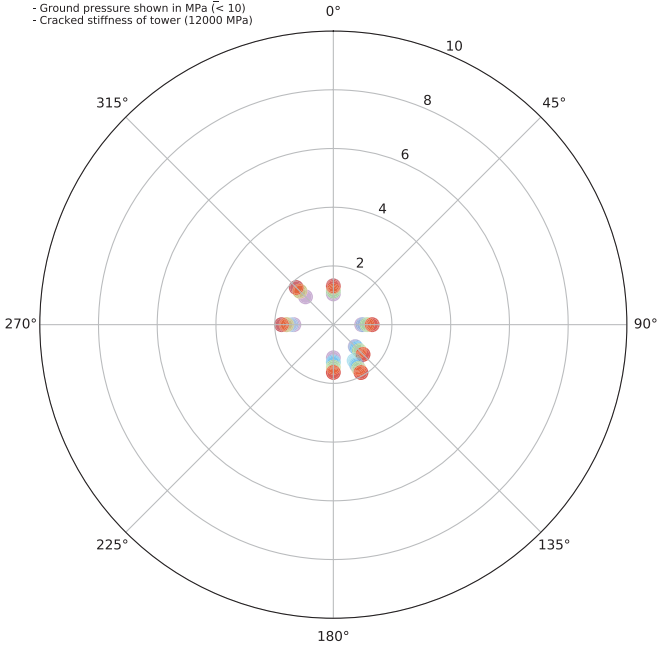
Check of ground pressure
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



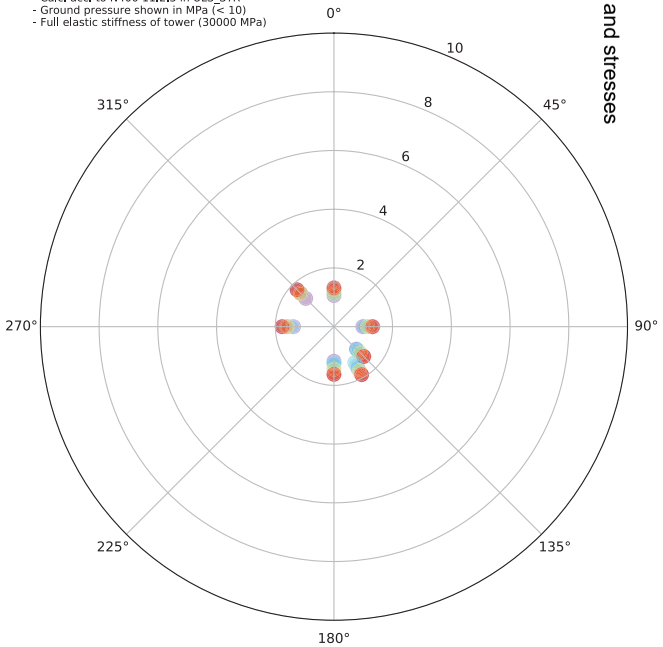
Check of ground pressure
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



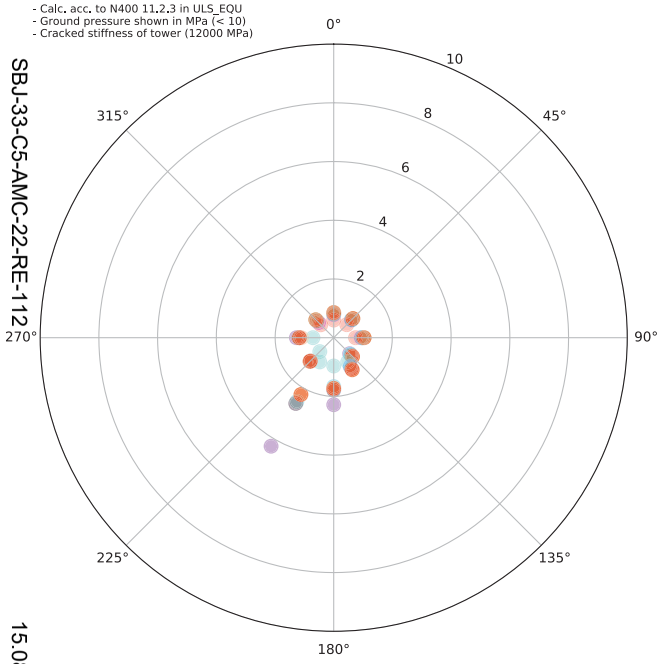
Check of ground pressure
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



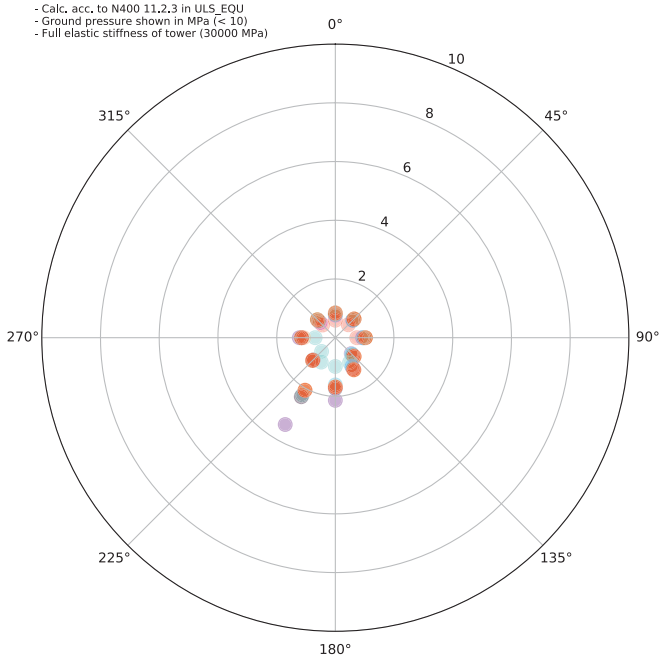
Check of ground pressure
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



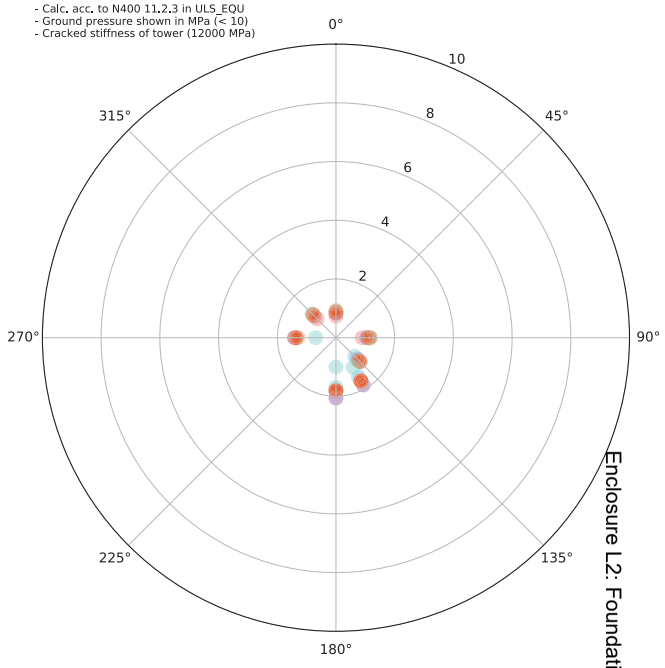
Check of ground pressure
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



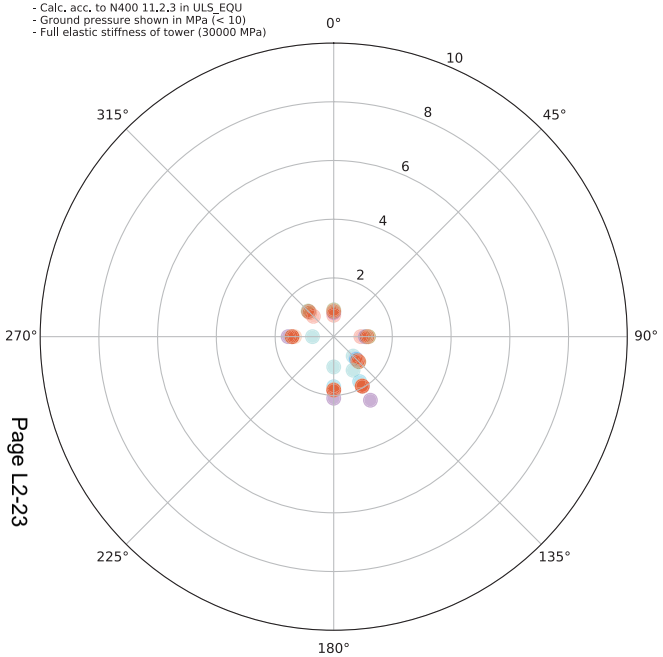
Check of ground pressure
Stage B - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



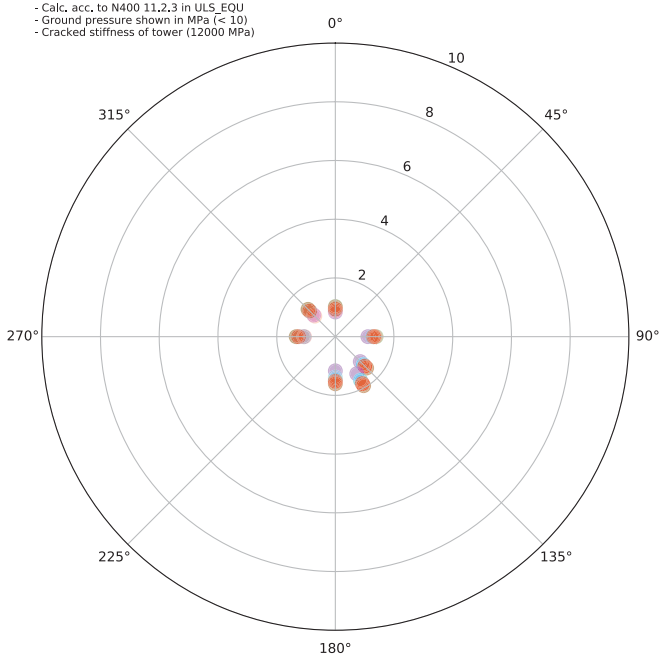
Check of ground pressure
Stage B - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



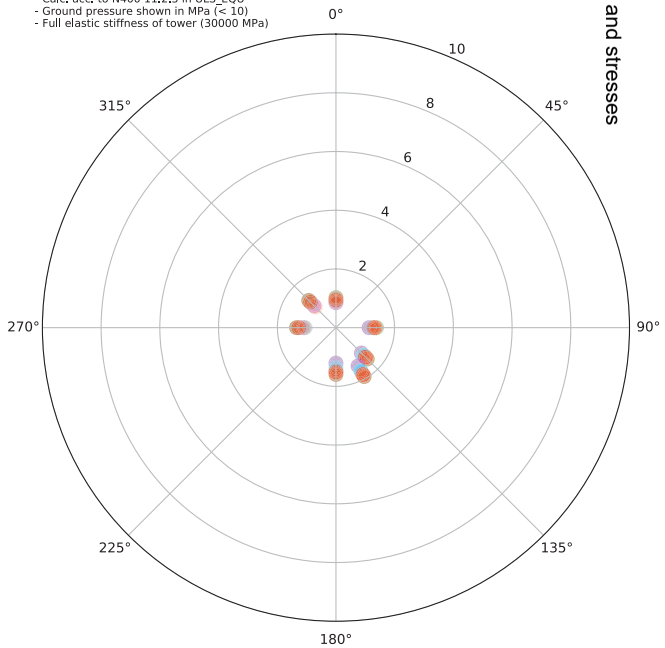
Check of ground pressure
Stage C - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



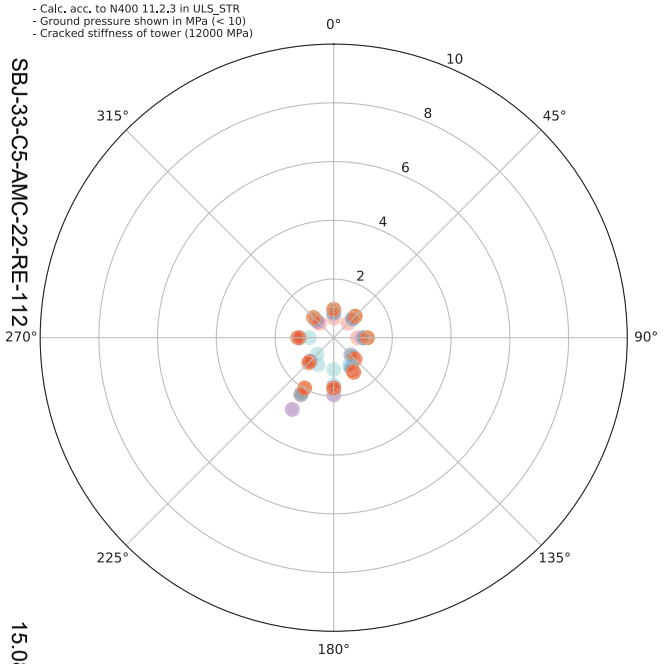
Check of ground pressure
Stage C - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_EQU
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



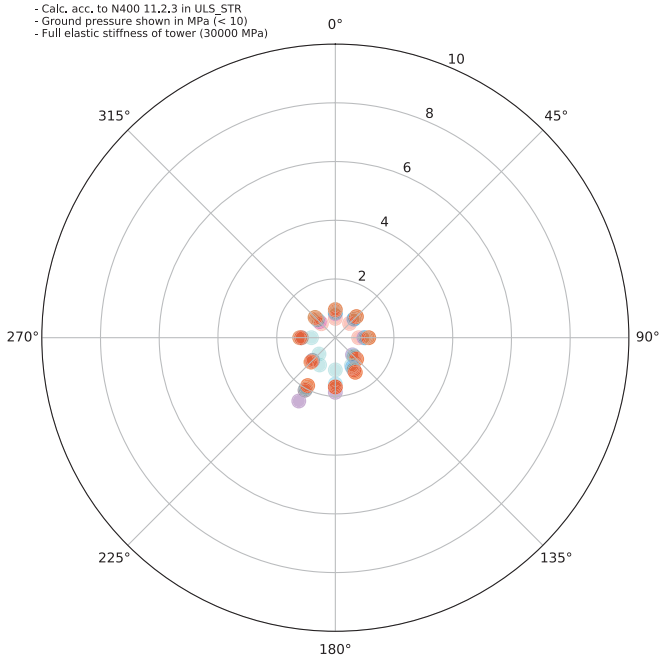
Check of ground pressure
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



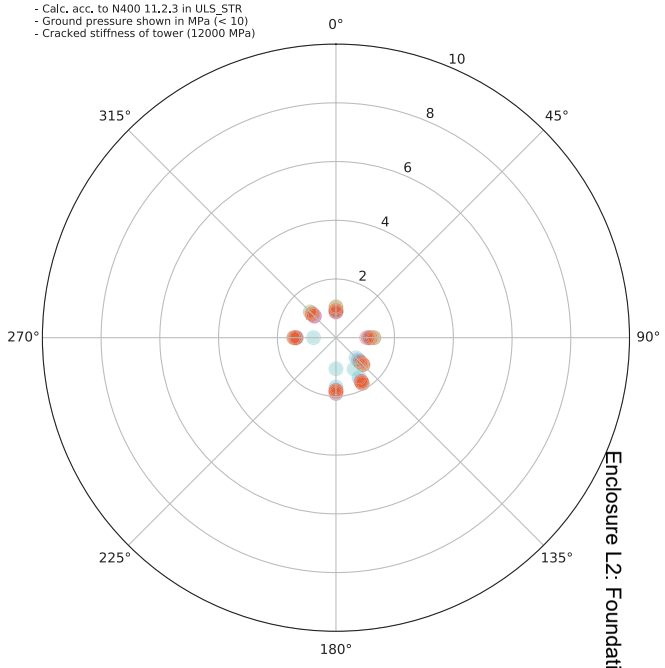
Check of ground pressure
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



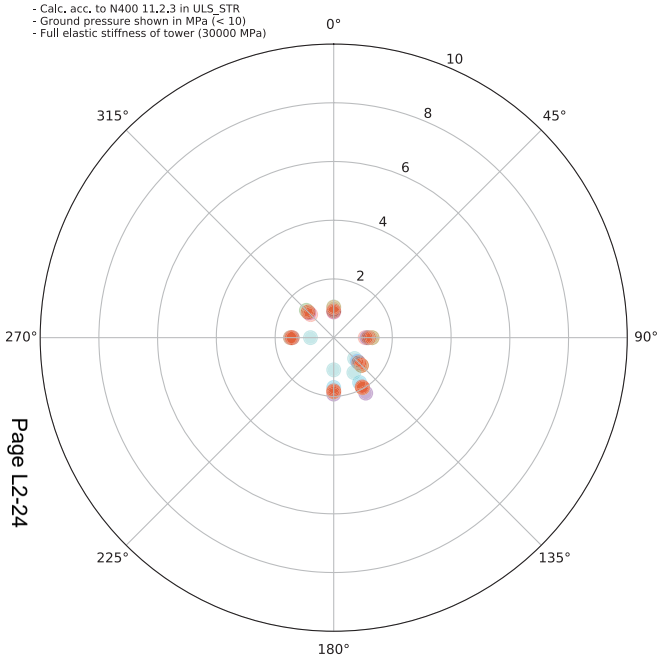
Check of ground pressure
Stage B - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



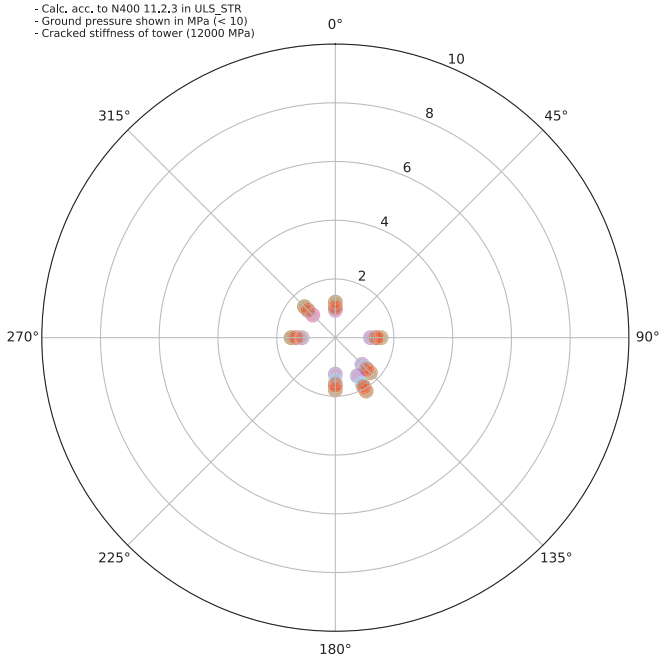
Check of ground pressure
Stage B - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



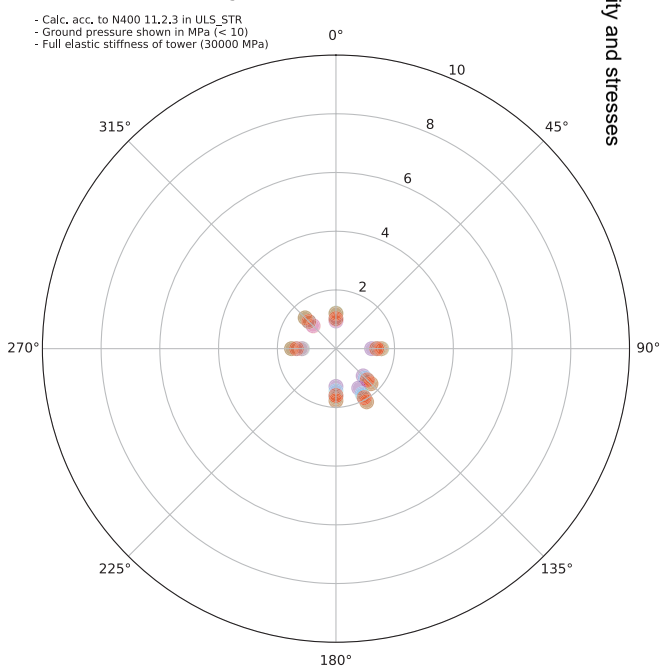
Check of ground pressure
Stage C - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Cracked stiffness of tower (12000 MPa)



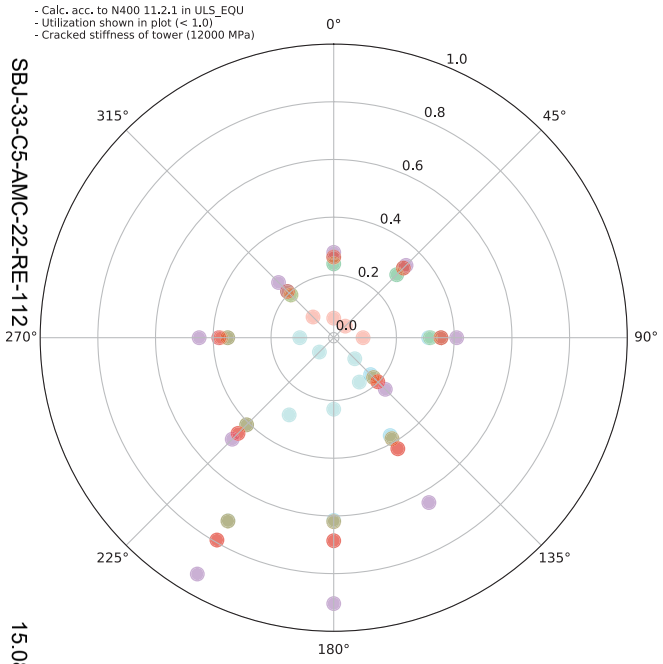
Check of ground pressure
Stage C - Western foundation

- Calc. acc. to N400 11.2.3 in ULS_STR
- Ground pressure shown in MPa (< 10)
- Full elastic stiffness of tower (30000 MPa)



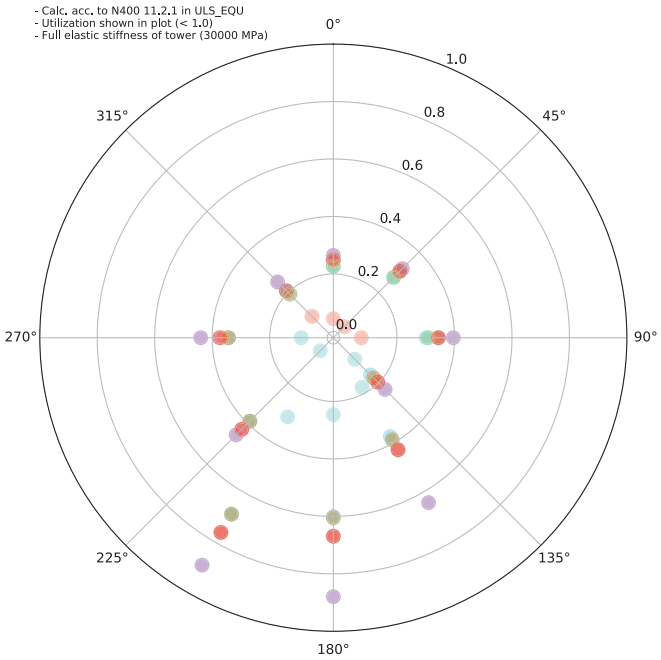
Check of overturning
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



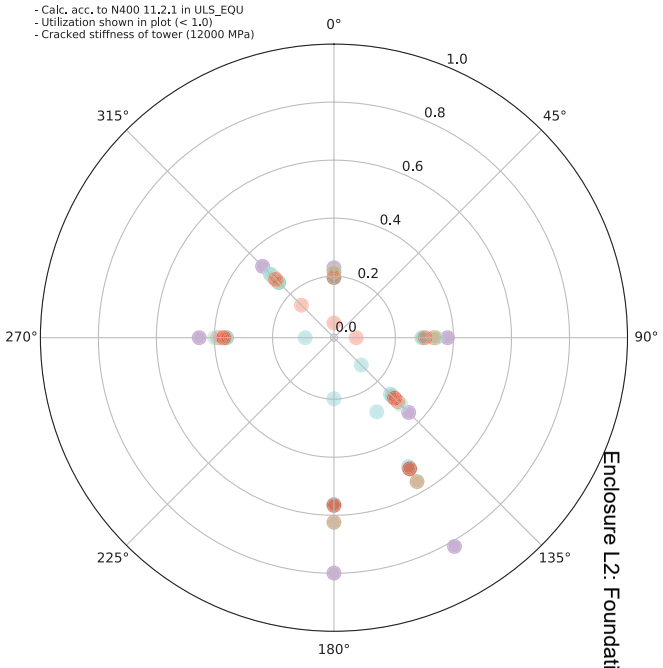
Check of overturning
Stage A2 - Eastern foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



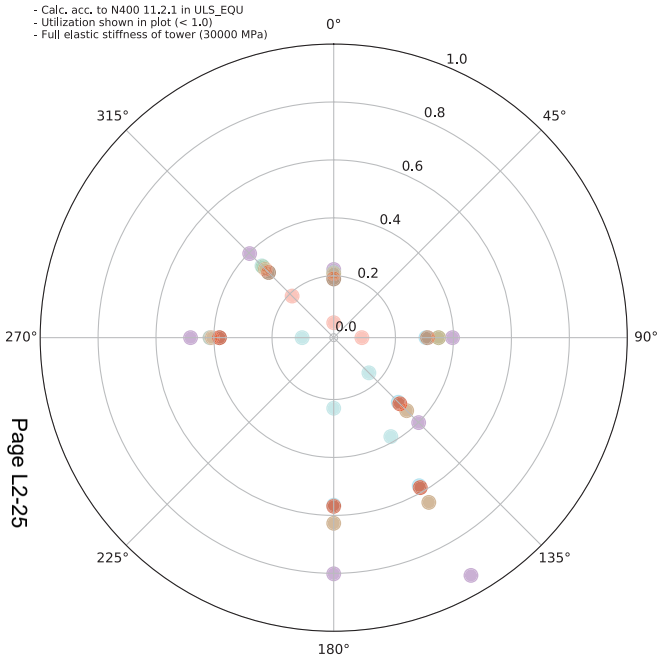
Check of overturning
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



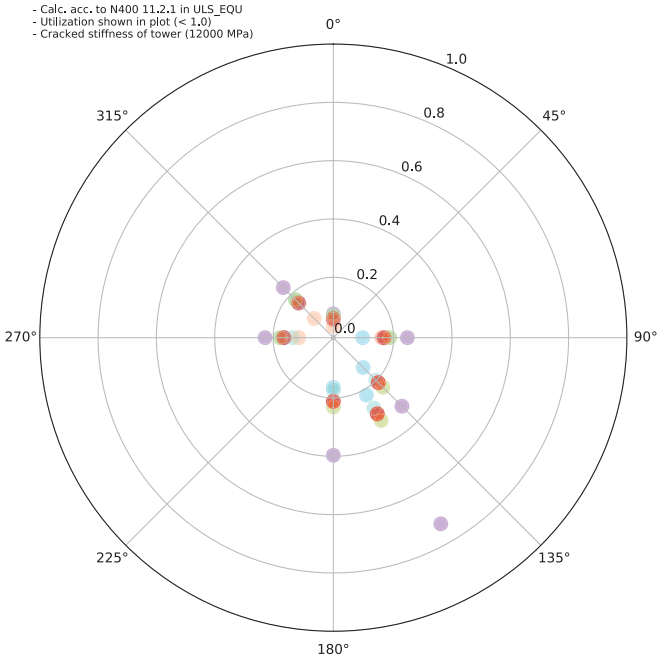
Check of overturning
Stage B - Eastern foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



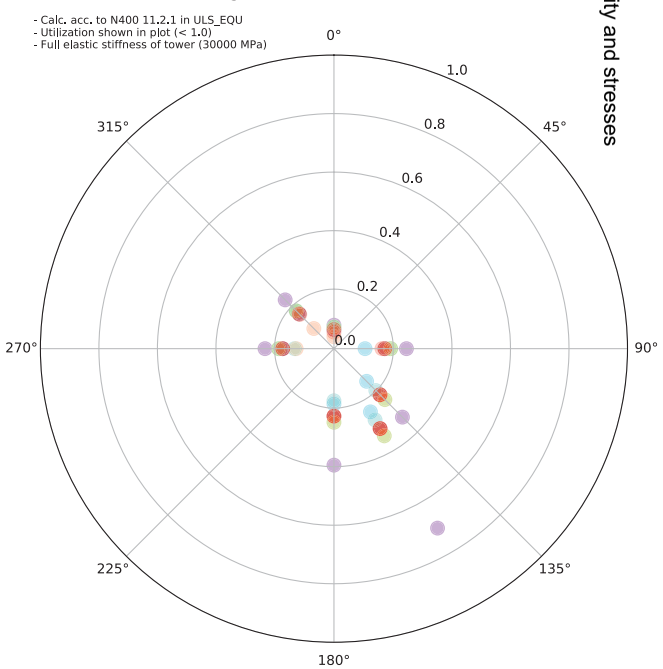
Check of overturning
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



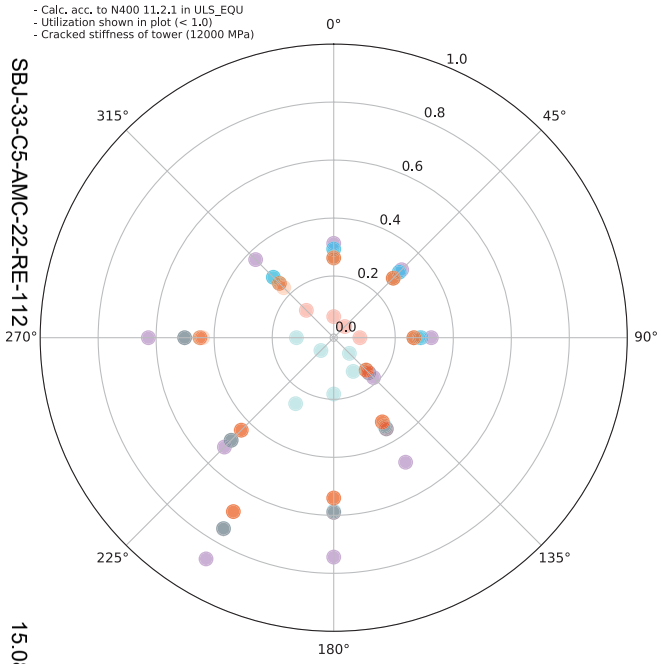
Check of overturning
Stage C - Eastern foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



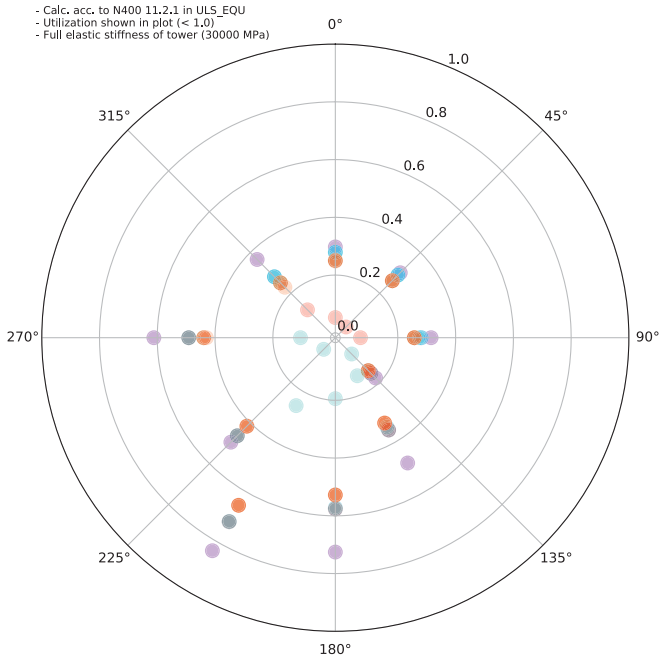
Check of overturning
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



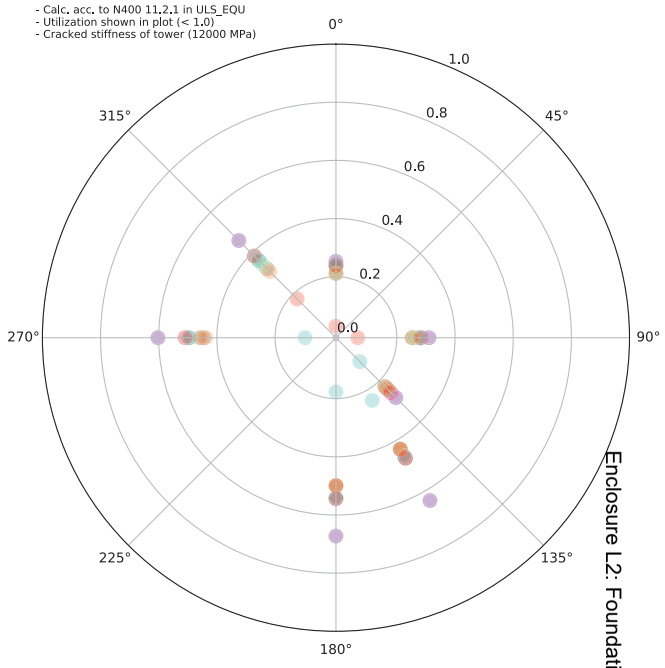
Check of overturning
Stage A2 - Western foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



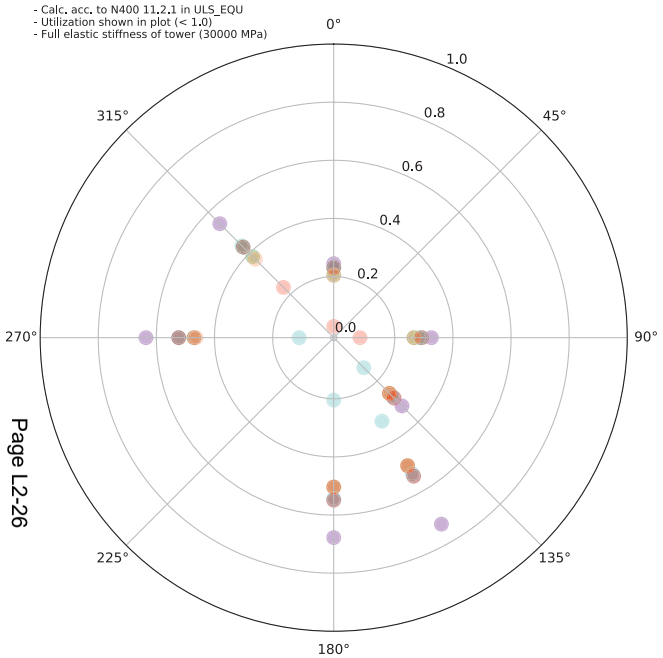
Check of overturning
Stage B - Western foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



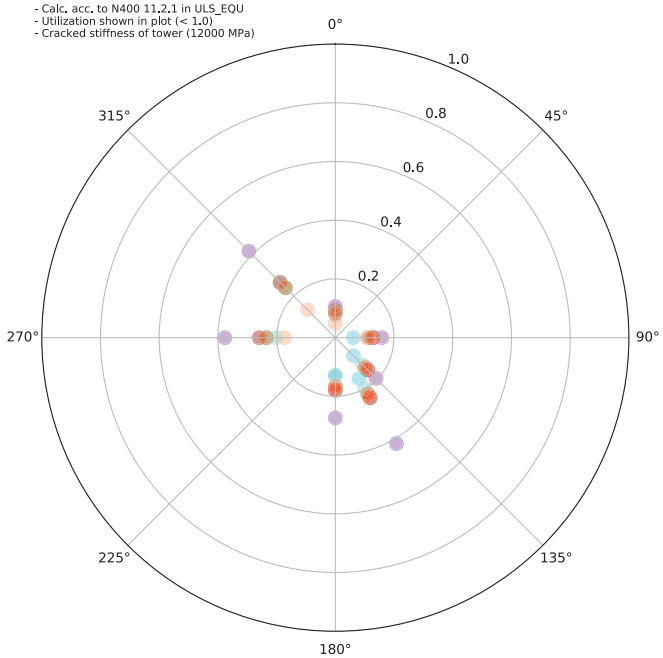
Check of overturning
Stage B - Western foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



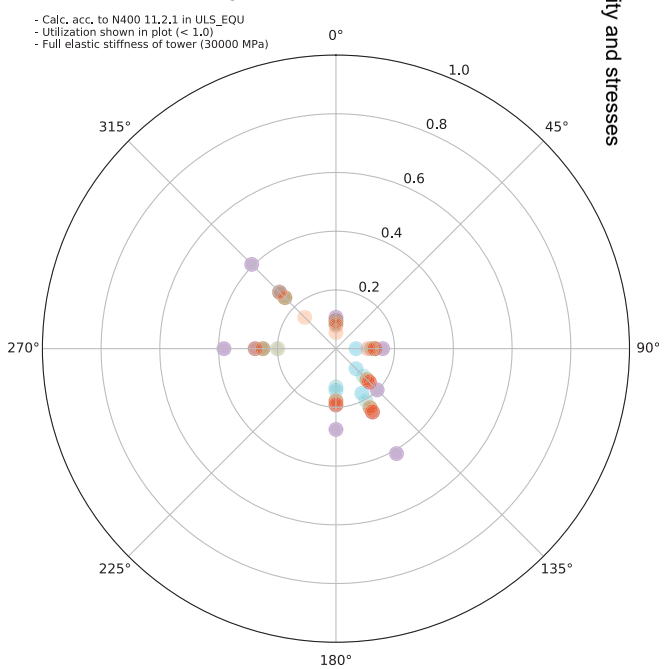
Check of overturning
Stage C - Western foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Cracked stiffness of tower (12000 MPa)



Check of overturning
Stage C - Western foundation

- Calc. acc. to N400 11.2.1 in ULS_EQU
- Utilization shown in plot (< 1.0)
- Full elastic stiffness of tower (30000 MPa)



5 Stability checks tower complete states

Analysis of construction stages

K12

Ground pressure tower ULS2

Forces from analysis

axis 2		Min N						Foundation sizes				eccentrivcity				ground pressure
		N	M longit	M transv	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
tag	pos															
easth	0	-271.76	-107.29	223.50	18.83	1.77	12.75	21	10	5.5	28875	-300.63	0.78	0.59	171.53	-1.75
west	0	-267.88	114.26	87.79	-12.94	0.32	-13.08	21	10	5.5	28875	-296.76	0.30	0.63	178.37	-1.66
		Min M longit														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth		-236.88	-213.71	117.35	16.76	0.75	18.49	21	10	5.5	28875	-265.75	0.46	1.19	153.18	-1.73
west		-232.72	78.17	-42.97	9.97	-0.38	-10.29	21	10	5.5	28875	-261.60	0.17	0.52	185.27	-1.41
		Min M transv														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth		-216.47	-173.24	-218.84	-14.01	-2.65	15.68	21	10	5.5	28875	-245.35	0.95	1.06	150.58	-1.63
west		-237.29	100.56	-226.08	20.68	-2.77	-11.77	21	10	5.5	28875	-266.16	0.91	0.62	168.04	-1.58

axis		Max N						Foundation sizes			eccentrivcity					ground pressure
		N	M longit	M transv	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
easth		-202.63	-176.67	-21.09	-3.46	-0.03	15.68	21	10	5.5	28875	-231.50	0.09	1.14	160.88	-1.44
west		-200.07	199.62	73.97	-2.50	0.87	-17.01	21	10	5.5	28875	-228.95	0.34	1.28	151.11	-1.52
		Max M longit														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth		-240.30	-62.55	63.55	-4.00	0.70	9.53	21	10	5.5	28875	-269.18	0.25	0.43	187.48	-1.44
west		-235.12	230.45	201.62	-24.75	1.55	-19.43	21	10	5.5	28875	-264.00	0.80	1.28	144.48	-1.83
		Max M transv														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth		-251.53	-144.17	430.83	32.74	4.46	14.59	21	10	5.5	28875	-280.40	1.62	0.80	149.10	-1.88
west		-235.86	187.12	424.32	-30.66	4.41	-16.84	21	10	5.5	28875	-264.73	1.69	1.06	138.89	-1.91

Used formulaes:

N=Nanalysis+DN (N from analysis+weight from foundation)
el=Mtransv/N eccentricity in longitudinal direction
en=Mlongit/N eccentricity intransverse direction
A=(width-2*el)*(depth-2*en)
sigma=N/A

K12
Ground pressure tower ULS3

Axis 2

		Min N						Foundation sizes			eccentrivcity					ground pressure
		N	M longit (Mn sterk akse)	M transv (Ml svak akse)	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
tag	pos															
easth	0	-280.40	-16.26	119.13	0.89	1.18	7.74	21	10	5.5	28875	-309.3	0.41	0.19	194.20	-1.59
west	0	-270.05	27.17	-115.43	3.64	-1.95	-8.07	21	10	5.5	28875	-298.9	0.42	0.24	191.91	-1.56
		Min M longit														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth	0	-197.00	-277.85	-107.11	4.71	-1.54	21.59	21	10	5.5	28875	-225.9	0.51	1.76	129.62	-1.74
west	0	-245.01	2.23	-40.71	15.80	-0.33	-6.15	21	10	5.5	28875	-273.9	0.16	0.13	201.45	-1.36
		Min M transv														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth	0	-197.40	-235.86	-210.51	-3.16	-2.72	19.07	21	10	5.5	28875	-226.3	1.00	1.51	132.82	-1.70
west	0	-247.82	36.77	-235.65	20.57	-3.17	-8.20	21	10	5.5	28875	-276.7	0.91	0.30	180.36	-1.53

		Max N						Foundation sizes				eccentrivcity				ground pressure
		N	M longit	M transv	T	V longit	V transv	Width	Depth	Height	DN	N	el	en	A	sigma
		MN	MNm	MNm	MNm	MN	MN	m	m	m	KN	MN	m	m	m2	Mpa
easth	0	-178.87	-245.35	-46.00	6.06	-0.23	19.28	21	10	5.5	28875	-207.7	0.23	1.69	135.95	-1.53
west	0	-176.61	302.80	157.20	-16.29	2.41	-22.60	21	10	5.5	28875	-205.5	0.83	2.08	113.01	-1.82
		Max M longit														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth	0	-264.14	31.92	130.53	-2.57	1.98	4.51	21	10	5.5	28875	-293.0	0.48	0.19	192.59	-1.52
west	0	-188.68	309.01	89.73	-13.74	1.28	-23.21	21	10	5.5	28875	-217.6	0.44	2.01	120.37	-1.81
		Max M transv														
		N	M longit	M transv	T	V longit	V transv									
		MN	MNm	MNm	MNm	MN	MN									
easth	0	-259.34	-37.73	298.24	10.06	3.79	8.55	21	10	5.5	28875	-288.2	1.11	0.29	176.81	-1.63
west	0	-194.78	248.36	318.39	-22.26	4.19	-19.76	21	10	5.5	28875	-223.7	1.53	1.60	122.17	-1.83

Used formulaes:

N=Nanalysis+DN (N from analysis+weight from foundation)
el=Mtransv/N eccentricity in longitudinal direction
en=Mlongit/N eccentricity intransverse direction
A=(width-2*el)*(depth-2*en)
sigma=N/A

K12
Ground pressure tower PLS ship collision

easth leg

		Forces from ship collisionanalysis						Forces from permanent loads			sum bending moments		Foundation sizes					eccentrivcity			ground pressure
		Axial	Shear force		Bending moment	Bending moment		permanent load			Bending moment	Bending moment	Width	Depth	Height	DN	N	el	en	A	sigma
		force [MN]	longitudinal [MN	orce transvers	roll [MNm]	pitch [MNm]	rsional moment [MN	N	M longit	M transv	roll [MNm]	pitch [MNm]	m	m	m	KN	MN	m	m	m2	Mpa
Max	Axial force [MN]	-127.9	7.3	7.4	335.1	416.5	107.2	-184.7	-114.9	-10.8	490.43	467.68	21	10	5.5	28875	-341.48	1.37	1.44	130.16	-2.62
Min	Axial force [MN]	-227.5	-7.893	-32.08	-112.3	-483.6	-117.3	-184.7	-114.9	-10.8	403.64	537.81	21	10	5.5	28875	-441.08	1.22	0.92	151.64	-2.91

west leg

		Forces from ship collisionanalysis						Forces from permanent loads			sum bending moments		Foundation sizes					eccentrivcity			ground pressure
		Axial	Shear force		Bending moment	Bending moment		permanent load			Bending moment	Bending moment	Width	Depth	Height	DN	N	el	en	A	sigma
		force [MN]	longitudinal [MN	orce transvers	roll [MNm]	pitch [MNm]	rsional moment [MN	N	M longit	M transv	roll [MNm]	pitch [MNm]	m	m	m	KN	MN	m	m	m2	Mpa
Max	Axial force [MN]	-121.5	7.386	29.08	91.83	412	102.1	-184.7	-114.9	-10.8	366.67	463.42	21	10	5.5	28875	-335.08	1.38	1.09	142.43	-2.35
Min	Axial force [MN]	-231	-8.352	-7.093	-365	-454.7	-100.6	-184.7	-114.9	-10.8	518.91	511.44	21	10	5.5	28875	-444.58	1.15	1.17	143.34	-3.10

Used formulaes:

N=Nanalysis+DN	(N from analysis+weight from foundation)
el=Mtransv/N	eccentricity in longitudinal direction
en=Mlongit/N	eccentricity intransverse direction
A=(width-2*el)*(depth-2*en)	
sigma=N/A	