Appendix to report:

SBJ-33-C5-OON-22-RE-012

STRUCTURAL RESPONSE ANALYSES

Appendix title:

APPENDIX C – COUPLED ANALYSES

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CONCEPT DEVELOPMENT FLOATING BRIDGE E39 BJØRNAFJORDEN

Norconsult

DR. TECHN. OLAV OLSEN

Prodtex IFE Pure Logic HEYERDAHL ARKITEKTER AS H&BB MIKO MARINE AS BUKSÉR OG BERGING FORCE TECHNOLOGY SWERIM

Table of Content

1 INTRODUCTION

In this report the coupled analyses performed are presented.

In Chapter 2 the environmental conditions are presented.

In Chapter 3 the response from the analyses are presented.

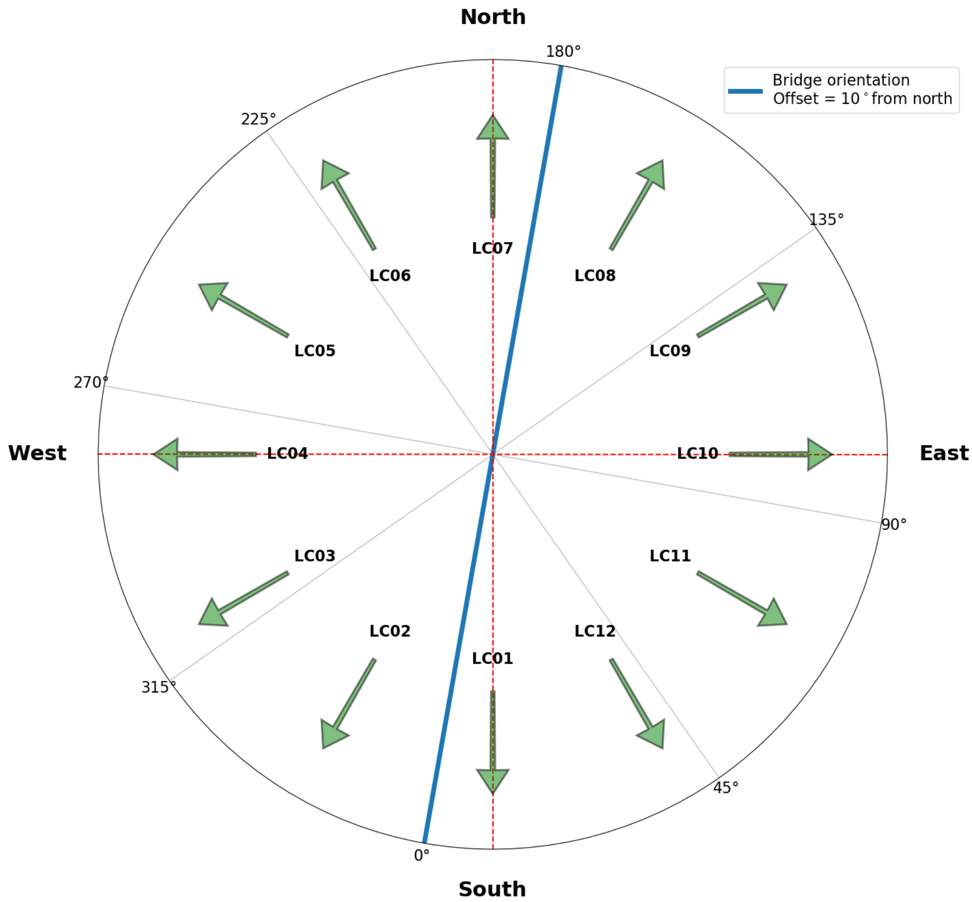
2 GOVERNING SEA STATES

In this chapter, the governing sea states concerning this concept are presented.

The coupled loads concerns static wind loads, turbulent wind loads and wave loads.

Among wave loads we need to consider that we have both waves from weather systems far away (Swell waves) and locally generated waves (Wind generated waves). In the global analyses performed for the final documentation both are included.

Figure 2-1 shows the wind generated sea direction and wind direction for the applied sea states. The swell is coming from 250 degrees for those sea-states where that is included.



> *Figure 2-1 Sea state directions relative to both bridge direction and cardinal coordinate system.*

More information with regards to the wave conditions and wind conditions are given in Table 2-1, Table 2-6 and Table 2-7, respectively. The wind generated waves are represented by spatially inhomogeneous sea-conditions where both Tp and Hs vary along the bridge. The variations are given as scaling factors and are presented in Table 2-2, Table 2-3, Table 2-4 and Table 2-5 for the different sea states.

2.1 Wind generated wave conditions with a 100 year return period

The Hs-values are increased by 4% due to global warming (Compared to values in design basis)

> *Table 2-1 Wave conditions, return period 100 year*

	Hs	Tp	Gamma	Wave Direction (from)	Spread, s
LC01	0.83	4.00	2.30	190	11
LC02	0.728	4.2	2.30	160	11
LC03	0.936	4.1	2.30	130	11
LC04	2.184	5.5	2.30	100	11
LC05	1.456	4.6	2.30	70	11
LC06	1.248	4	2.30	40	11
LC07	1.248	3.9	2.30	10	11
LC08	1.456	4.6	2.30	340	11
LC09	1.456	4	2.30	310	11
LC10	1.872	4.5	2.30	280	11
LC11	2.08	5.2	2.30	250	11
LC12	1.248	4.6	2.30	220	11

*s=2n+1

2.1.1 Scaling of Hs along bridge span

Here 325m indicates the position of the cable stayed tower while 5240m is the north landfall

> *Table 2-2 Scalefactors Hs (LC01-LC06)*

Position along X [m]	LC01	LC02	LC03	LC04	LC05	LC06
325	1.28	1.21	1.16	0.82	0.65	0.49
725	1.28	1.21	1.16	0.82	0.65	0.49
925	1.26	1.2	1.15	0.86	0.7	0.56
1125	1.25	1.19	1.14	0.88	0.74	0.62
1325	1.23	1.17	1.13	0.91	0.78	0.68
1525	1.21	1.16	1.12	0.93	0.81	0.73
1725	1.18	1.14	1.11	0.95	0.85	0.77
1925	1.16	1.12	1.1	0.96	0.87	0.82
2125	1.13	1.1	1.08	0.98	0.9	0.86
2325	1.1	1.08	1.06	0.99	0.93	0.89
2525	1.07	1.06	1.04	0.99	0.95	0.93
2725	1.04	1.03	1.02	1	0.97	0.96
2925	1	1	1	1	1	1
3125	0.96	0.97	0.97	1	1.02	1.03
3325	0.92	0.93	0.94	1	1.04	1.05
3525	0.87	0.89	0.91	1	1.05	1.08
3725	0.82	0.84	0.87	0.99	1.07	1.11
3925	0.75	0.78	0.83	0.99	1.08	1.13
4125	0.68	0.72	0.79	0.98	1.1	1.16
4325	0.6	0.64	0.74	0.97	1.11	1.18
4525	0.51	0.56	0.69	0.96	1.11	1.19
4725	0.4	0.46	0.63	0.95	1.11	1.21
5125	0.4	0.46	0.63	0.95	1.11	1.21
5240	0.4	0.46	0.63	0.95	1.11	1.21

> *Table 2-3 Scalefactors Hs (LC07-LC12)*

Position along X [m]	LC07	LC08	LC09	LC10	LC11	LC12
325	0.34	0.35	0.57	0.79	1.06	1.19
725	0.34	0.35	0.57	0.79	1.06	1.19
925	0.44	0.45	0.64	0.83	1.07	1.18
1125	0.52	0.53	0.69	0.86	1.07	1.17
1325	0.6	0.61	0.74	0.89	1.07	1.16
1525	0.67	0.68	0.79	0.91	1.07	1.14
1725	0.73	0.74	0.83	0.93	1.06	1.12
1925	0.79	0.8	0.86	0.94	1.05	1.1
2125	0.84	0.84	0.89	0.96	1.04	1.09
2325	0.88	0.89	0.92	0.97	1.03	1.07
2525	0.92	0.93	0.95	0.98	1.02	1.05
2725	0.96	0.96	0.97	0.99	1.01	1.03
2925	0.99	1	1	1	1	1
3125	1.03	1.03	1.02	1.01	0.99	0.98
3325	1.06	1.05	1.04	1.01	0.97	0.95
3525	1.08	1.08	1.06	1.02	0.94	0.91
3725	1.11	1.1	1.08	1.02	0.91	0.86
3925	1.13	1.12	1.09	1.02	0.87	0.8
4125	1.15	1.14	1.1	1.01	0.81	0.73
4325	1.17	1.16	1.11	1	0.74	0.64
4525	1.18	1.17	1.12	0.98	0.65	0.53
4725	1.2	1.18	1.12	0.94	0.53	0.4
5125	1.2	1.18	1.12	0.94	0.53	0.4
5240	1.2	1.18	1.12	0.94	0.53	0.4

2.1.2 Scaling of Tp along bridge span

Here 325m indicates the position of the cable stayed tower while 5240m is the north landfall

> *Table 2-4 Scalefactors Tp (LC01-LC06)*

Position along X [m]	LC01	LC02	LC03	LC04	LC05	LC06
325	1.01	1.04	1.04	0.99	1	0.8
725	1.01	1.04	1.04	0.99	1	0.8
925	1	1.05	1.04	1	1	0.82
1125	0.99	1.06	1.04	1	1	0.83
1325	0.99	1.06	1.04	1	1	0.85
1525	0.98	1.07	1.04	1	1	0.87
1725	0.98	1.06	1.03	1	1	0.88
1925	0.98	1.06	1.03	1	1	0.9
2125	0.98	1.05	1.02	1	1	0.92
2325	0.98	1.04	1.02	1	1	0.94
2525	0.98	1.02	1.01	1	1	0.96
2725	0.98	1.01	1.01	1	1	0.98
2925	0.97	0.98	1	1	1	1
3125	0.96	0.96	0.99	1	1	1.01
3325	0.94	0.93	0.99	1	1	1.03
3525	0.92	0.89	0.98	1	1.01	1.04
3725	0.89	0.85	0.97	0.99	1.01	1.05
3925	0.85	0.81	0.96	0.99	1.01	1.06
4125	0.81	0.76	0.96	0.99	1.02	1.06
4325	0.76	0.7	0.95	0.99	1.02	1.07
4525	0.69	0.64	0.94	0.99	1.03	1.07
4725	0.62	0.58	0.93	0.99	1.03	1.07
5125	0.62	0.58	0.93	0.99	1.03	1.07
5240	0.62	0.58	0.93	0.99	1.03	1.07

> *Table 2-5 Scalefactors Tp (LC07-LC12)*

Position along X [m]	LC07	LC08	LC09	LC10	LC11	LC12
325	0.51	0.48	0.84	0.97	1.03	1.05
725	0.51	0.48	0.84	0.97	1.03	1.05
925	0.55	0.56	0.85	0.97	1.03	1.04
1125	0.6	0.64	0.87	0.98	1.02	1.03
1325	0.64	0.7	0.88	0.98	1.02	1.02
1525	0.69	0.76	0.9	0.98	1.02	1.02
1725	0.73	0.81	0.91	0.98	1.01	1.01
1925	0.78	0.86	0.92	0.98	1.01	1.01
2125	0.82	0.9	0.94	0.99	1.01	1.01
2325	0.86	0.93	0.95	0.99	1.01	1.01
2525	0.9	0.96	0.97	0.99	1.01	1.01
2725	0.94	0.98	0.98	1	1.01	1.01
2925	0.97	1	1	1	1.01	1.01
3125	1	1.02	1.01	1	1	1.01
3325	1.02	1.03	1.02	1.01	1	1
3525	1.04	1.04	1.03	1.01	0.99	1
3725	1.06	1.05	1.04	1.01	0.98	0.99
3925	1.06	1.05	1.05	1.01	0.96	0.98
4125	1.07	1.05	1.06	1.01	0.94	0.96
4325	1.06	1.05	1.07	1.01	0.92	0.94
4525	1.06	1.06	1.07	1.01	0.9	0.92
4725	1.04	1.06	1.07	1.01	0.87	0.89
5125	1.04	1.06	1.07	1.01	0.87	0.89
5240	1.04	1.06	1.07	1.01	0.87	0.89

2.2 Swell wave conditions with a 100 year return period

> *Table 2-6 Wave conditions swell*

	Hs	Tp	Gamma	Wave Direction (from)	Spread, s
LC01	0.34	16.0	5.0	250	31
LC02	-	-	-	-	-
LC03	-	-	-	-	-
LC04	-	-	-	-	-
LC05	-	-	-	-	-
LC06	-	-	-	-	-
LC07	0.34	16.0	5.0	250	31
LC08	0.34	16.0	5.0	250	31
LC09	0.34	16.0	5.0	250	31
LC10	0.34	16.0	5.0	250	31
LC11	0.34	16.0	5.0	250	31
LC12	0.34	16.0	5.0	250	31

*s=2n+1

2.3 Wind conditions with a 100 year return period

The wind speed-values are increased by 4% due to global warming (Compared to values in design basis)

> *Table 2-7 Wind conditions*

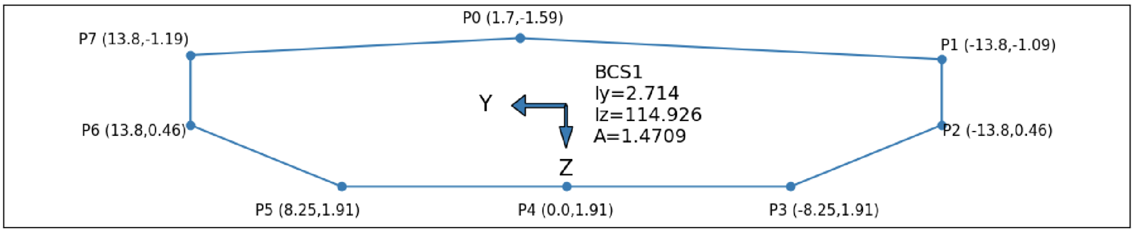
Load case	Wind Spectrum	Wind speed at ref height	Turbulence intensity	Ref wind height	Wind Profile	Wind Exp	z,0	Wind Dir (from)
[-]	[-]	[m/s]	[-]	[m]	[-]	[.]	[m]	[Deg]
LC01	Kaimal	21.55	14%	10	Power Law	0.13	0.01	190
LC02	Kaimal	21.55	14%	10	Power Law	0.13	0.01	160
LC03	Kaimal	21.55	14%	10	Power Law	0.13	0.01	130
LC04	Kaimal	26.17	14%	10	Power Law	0.13	0.01	100
LC05	Kaimal	26.17	14%	10	Power Law	0.13	0.01	70
LC06	Kaimal	26.17	23.5%	10	Power Law	0.13	0.01	40
LC07	Kaimal	26.17	23.5%	10	Power Law	0.13	0.01	10
LC08	Kaimal	26.17	23.5%	10	Power Law	0.13	0.01	340
LC09	Kaimal	27.71	14%	10	Power Law	0.13	0.01	310
LC10	Kaimal	30.78	14%	10	Power Law	0.13	0.01	280
LC11	Kaimal	30.78	14%	10	Power Law	0.13	0.01	250
LC12	Kaimal	30.78	14%	10	Power Law	0.13	0.01	220

3 RESPONSE

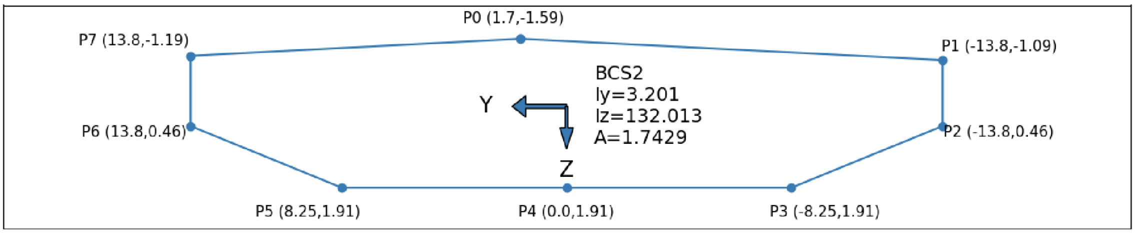
The response can currently be found on the webpage olavolsen.interactive.no [1] for K12 – Model 27. Most relevant responses of the bridge girder are also presented here.

3.1 Stress points

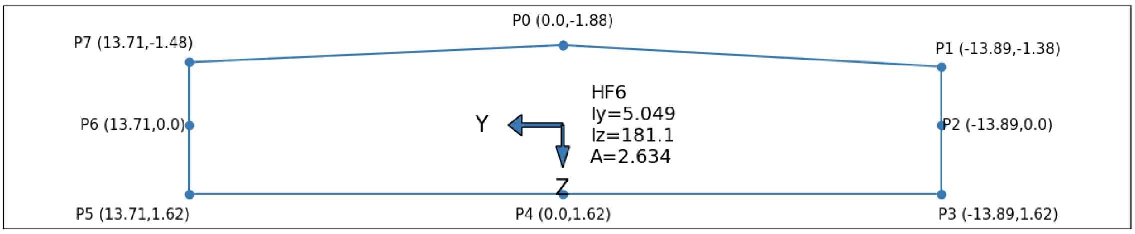
The stresses presented are given for different stress points in the bridge girder cross-section. The distribution of these stress points of the two main cross-sections of the bridge are shown in Figure 3-1, Figure 3-2 and Figure 3-3. For more information on the bridge girder cross-sections, see [2].



> *Figure 3-1 Distribution of stress points and local coordinate system of cross-section BCS1.*



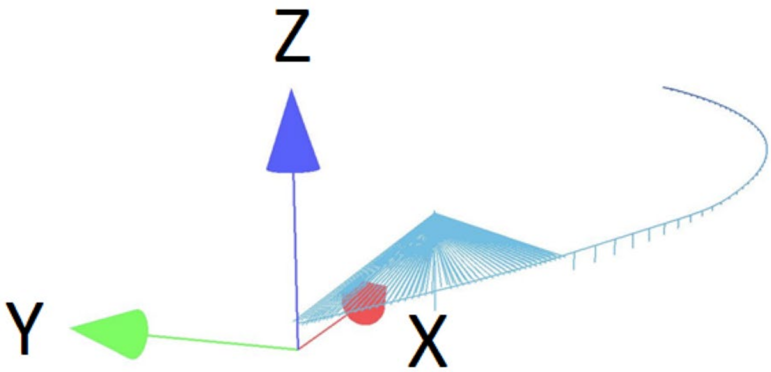
> *Figure 3-2 Distribution of stress points and local coordinate system of cross-section BCS2.*



> *Figure 3-3 Distribution of stress points and local coordinate system of cross-section HF6.*

3.2 Coordinate systems

Displacements and accelerations are presented according to the global coordinate system given in Figure 3-4.

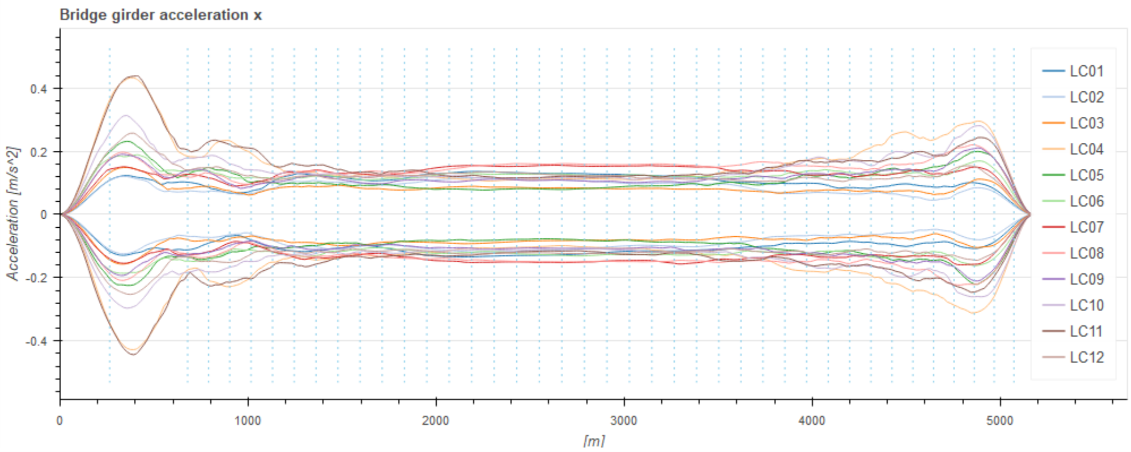


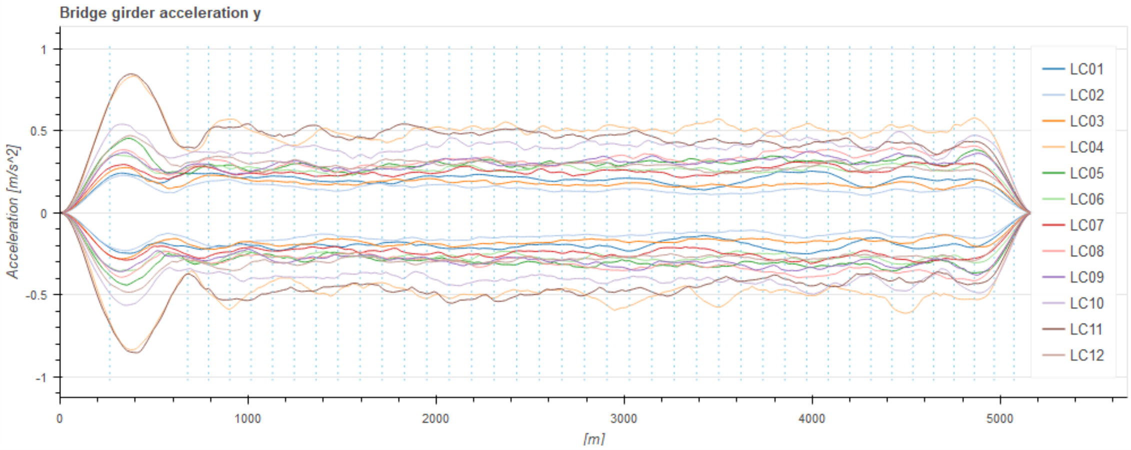
> *Figure 3-4 Global coordinate system*

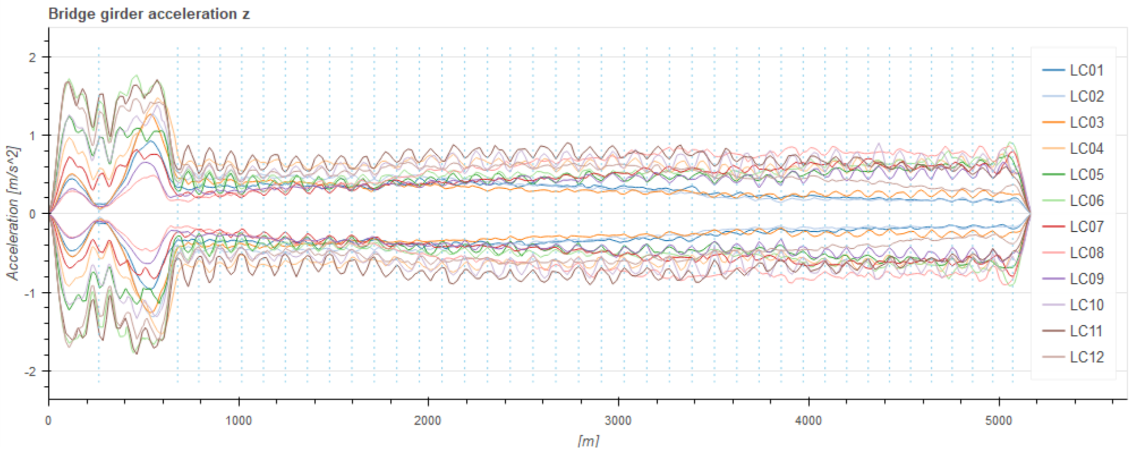
Forces and moments are presented according to the local coordinate systems presented in Figure 3-1, Figure 3-2 and Figure 3-3.

3.3 Acceleration

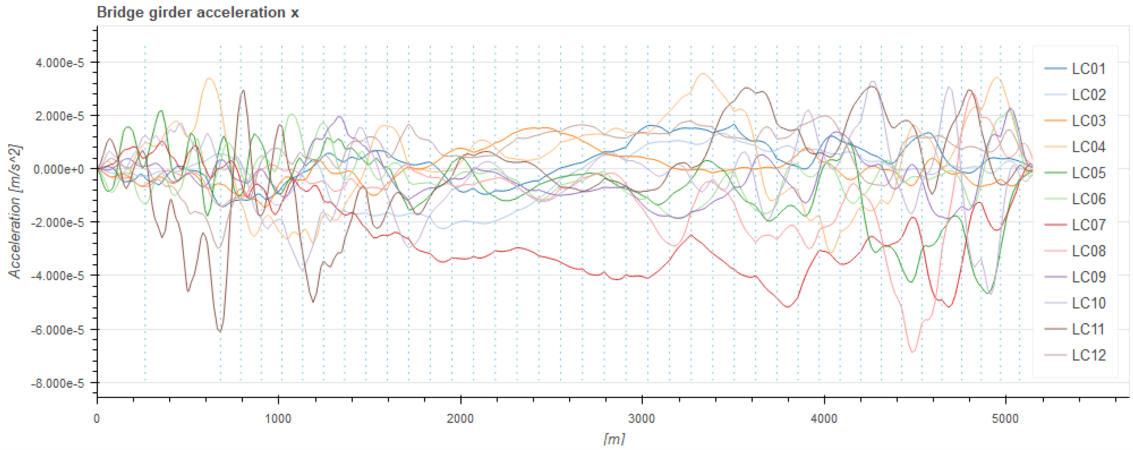
3.3.1 Max/min response

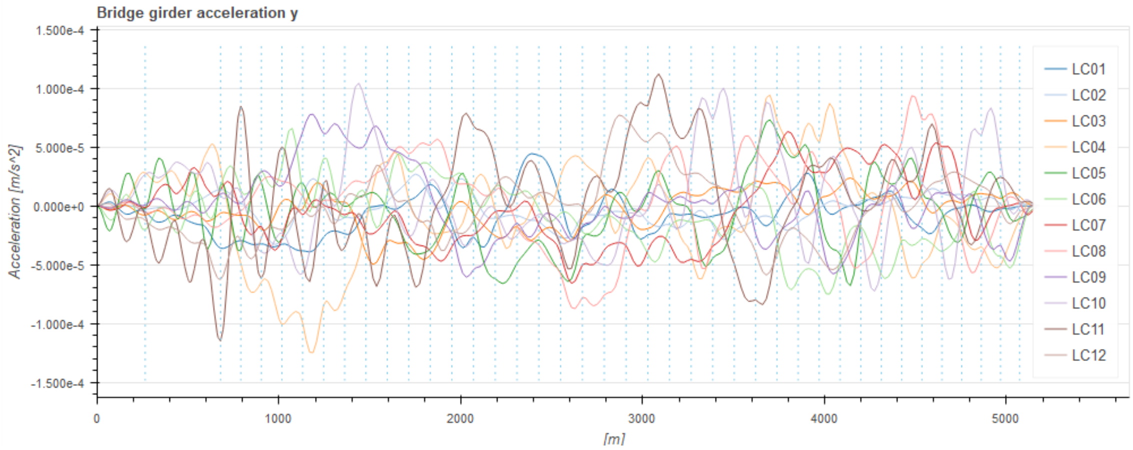


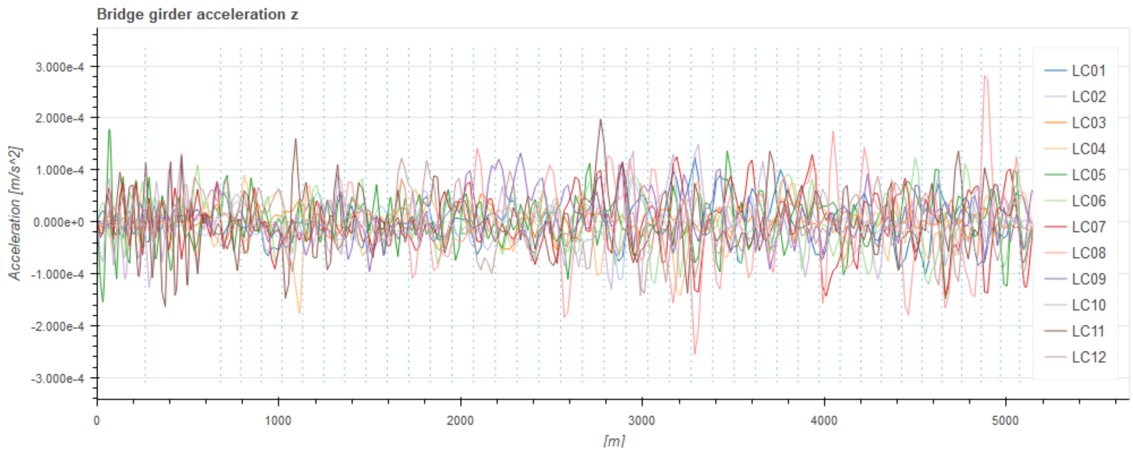




3.3.2 Mean response

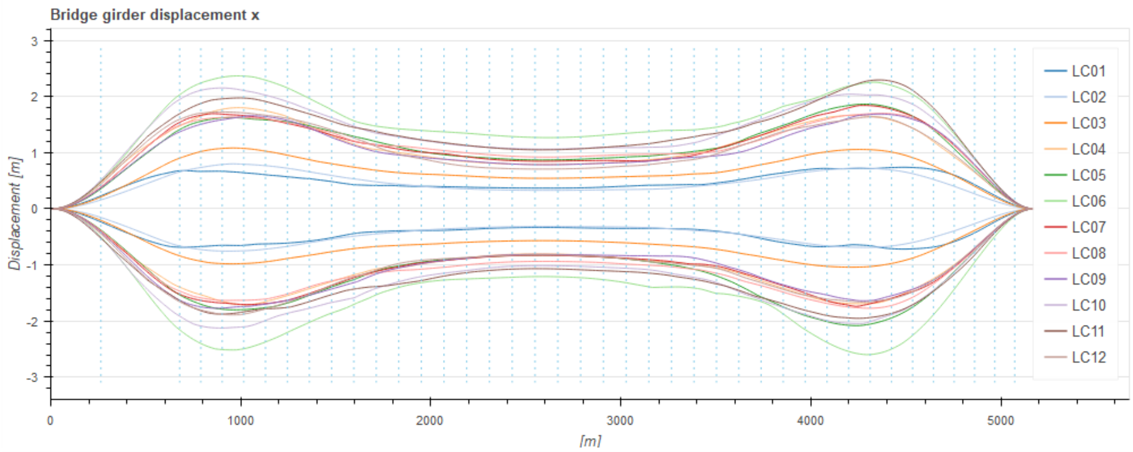


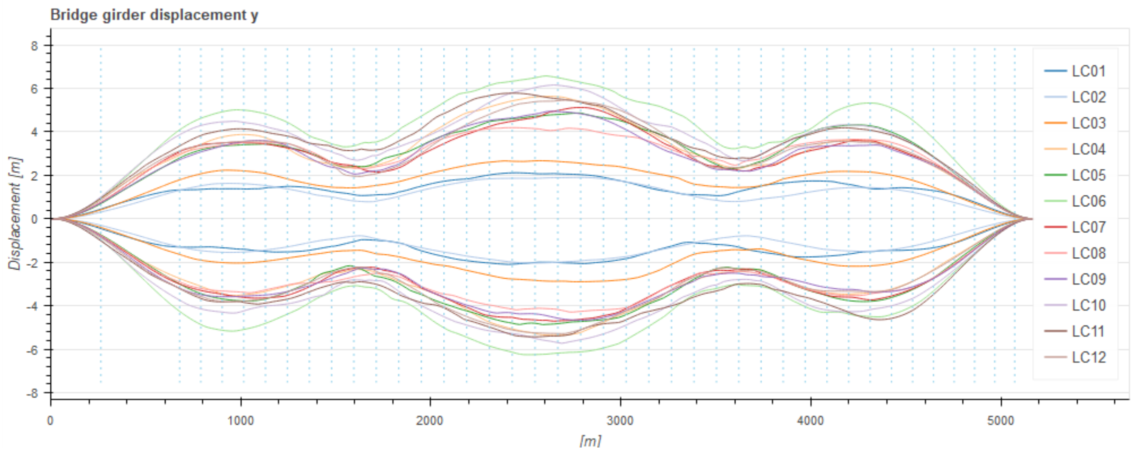




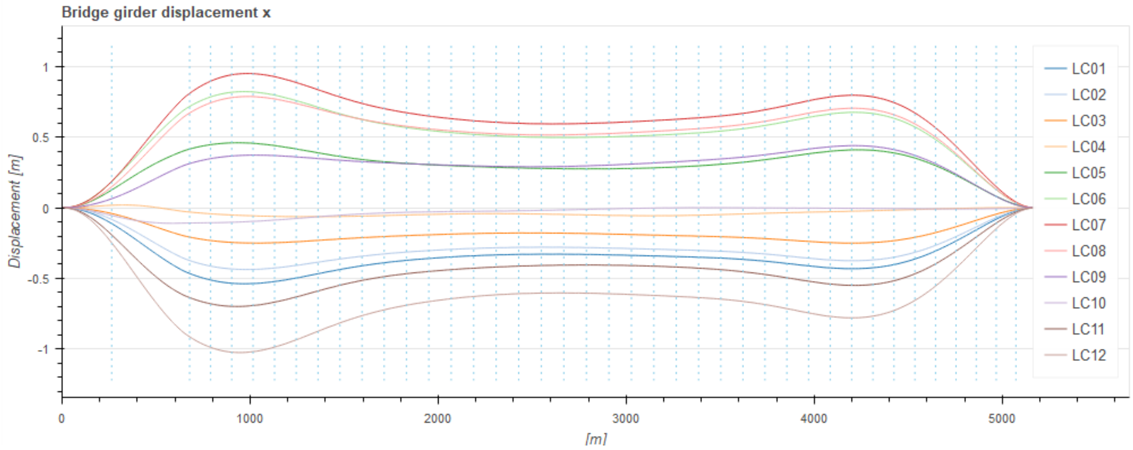
3.4 Displacement

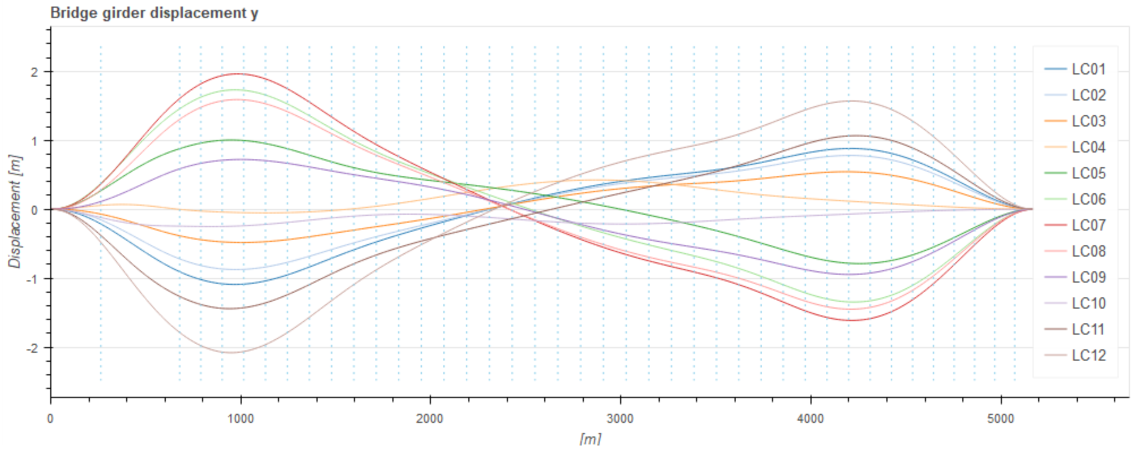
3.4.1 Max/min response

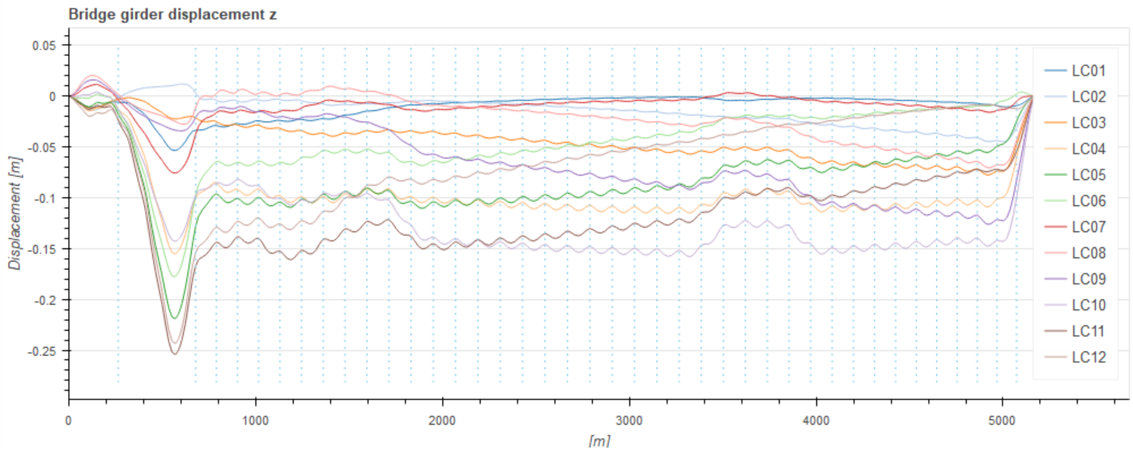




3.4.2 Mean response

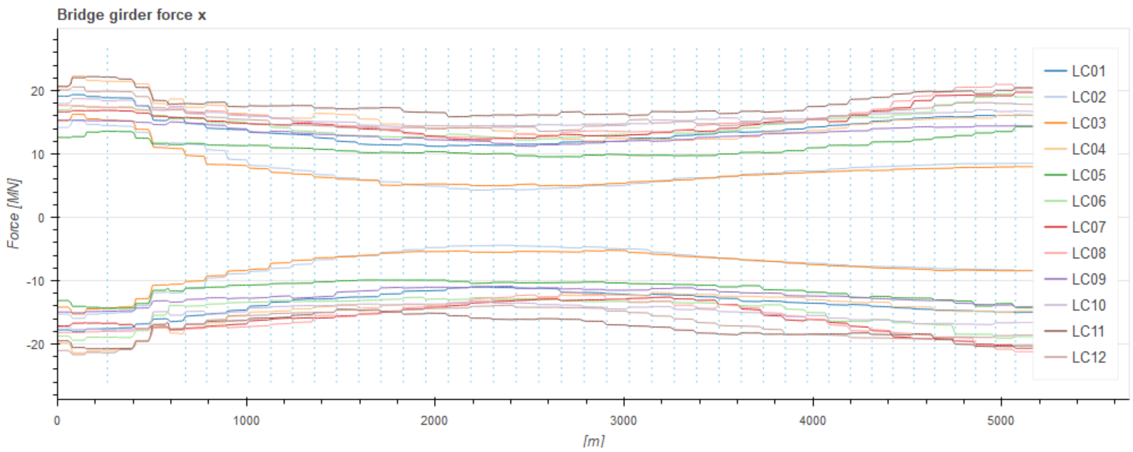


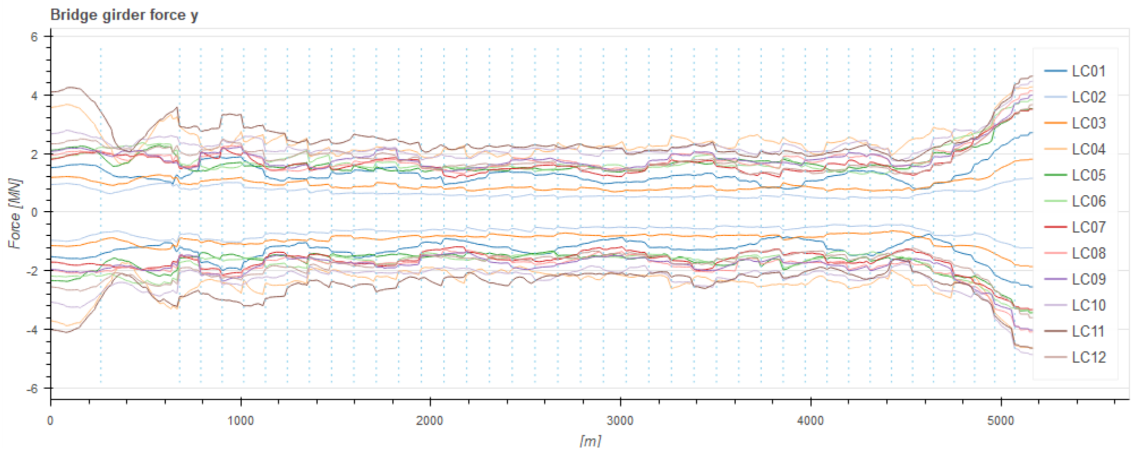


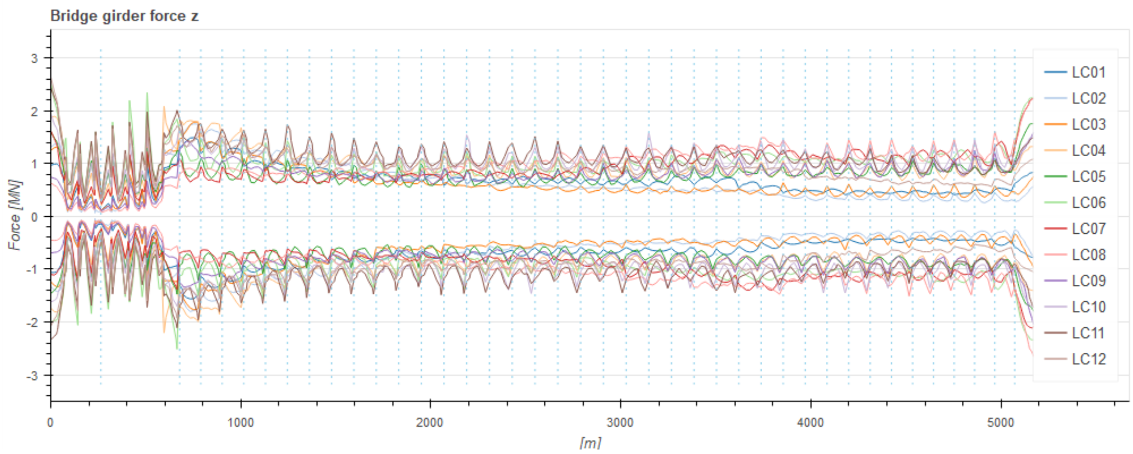


3.5 Force

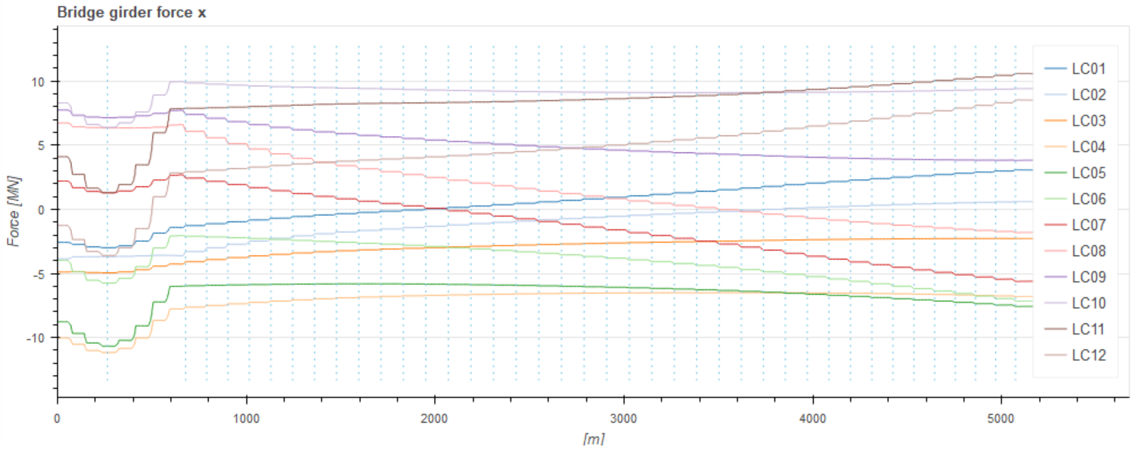
3.5.1 Max/min response

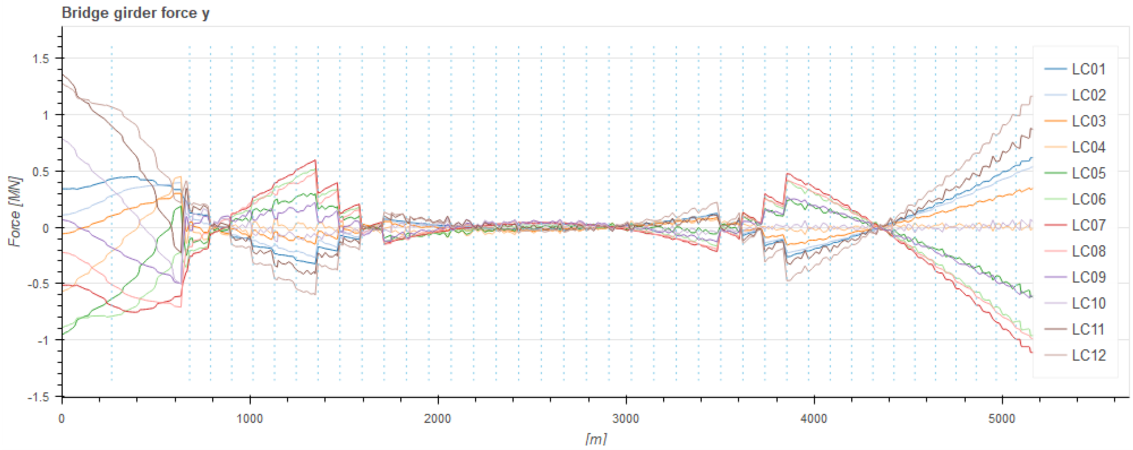


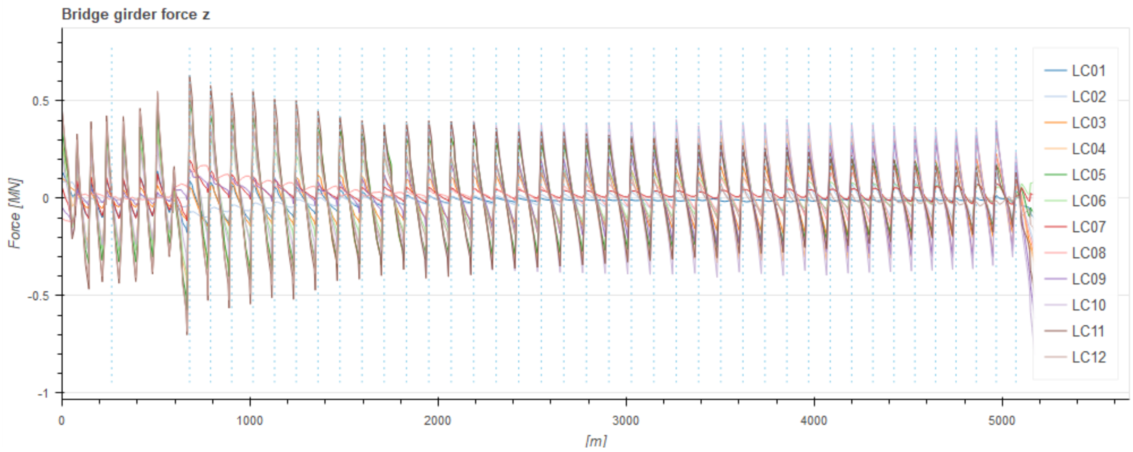




3.5.2 Mean response

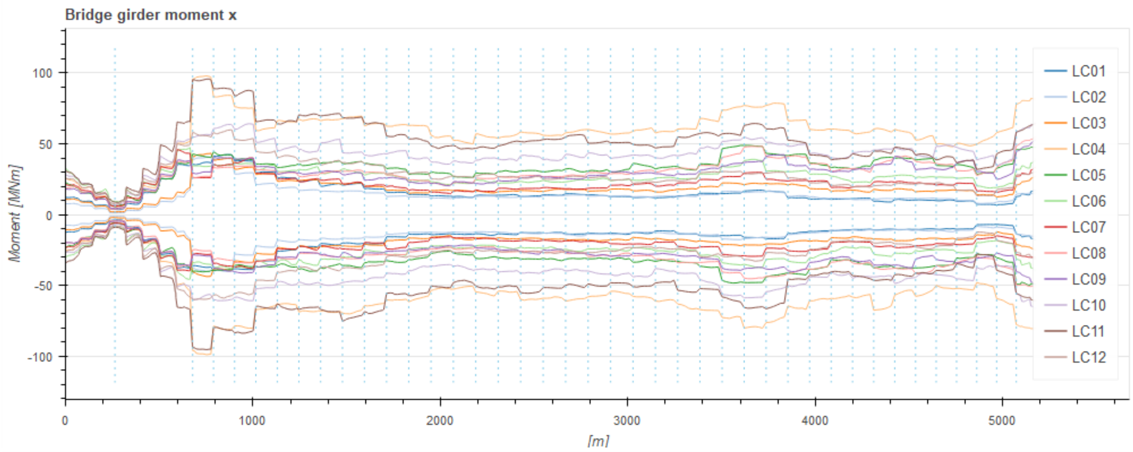


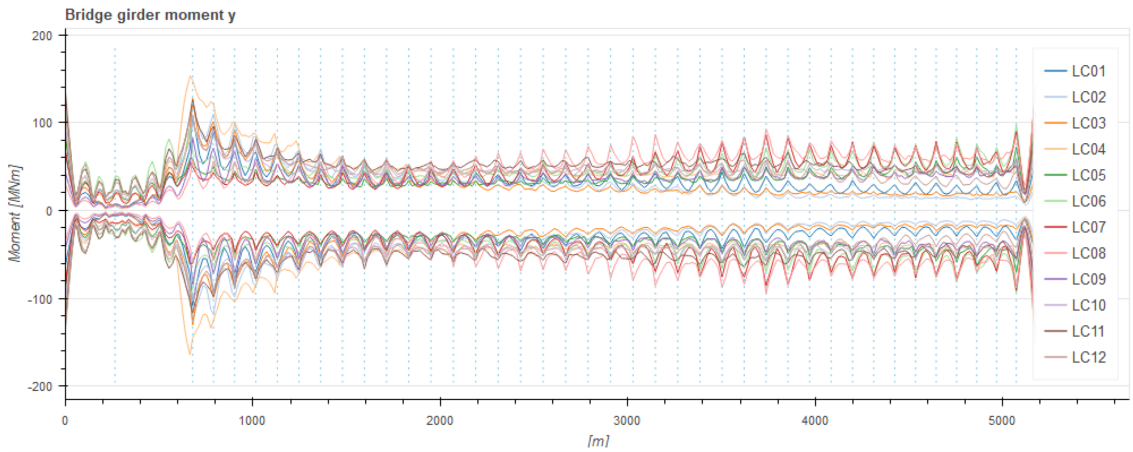


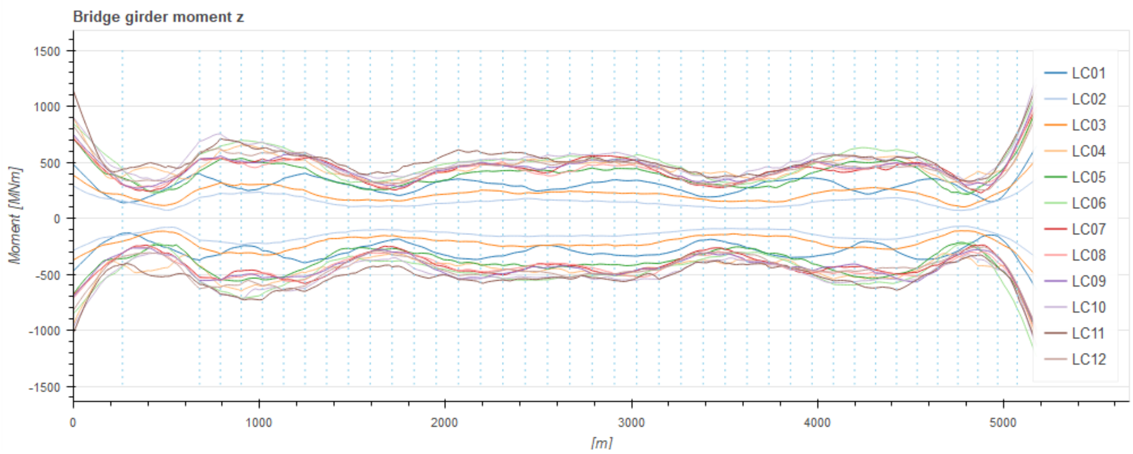


3.6 Moment

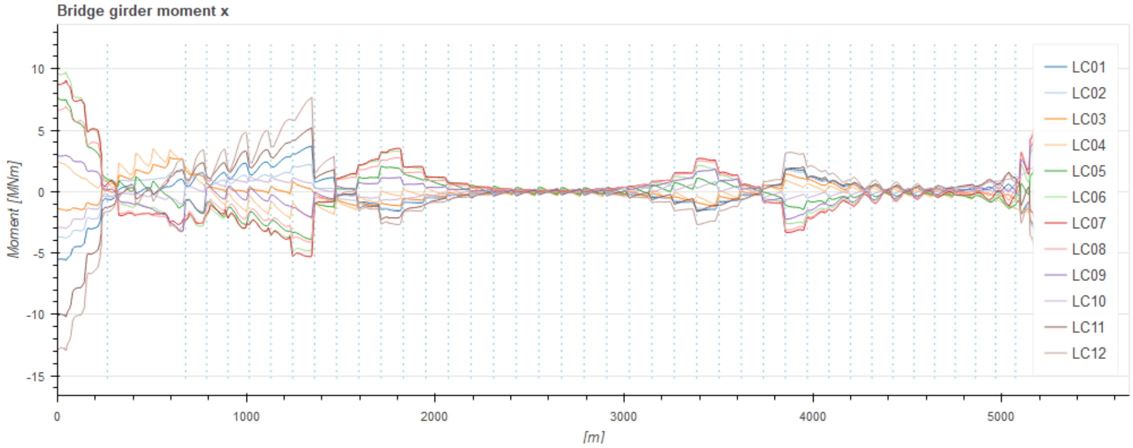
3.6.1 Max/min response

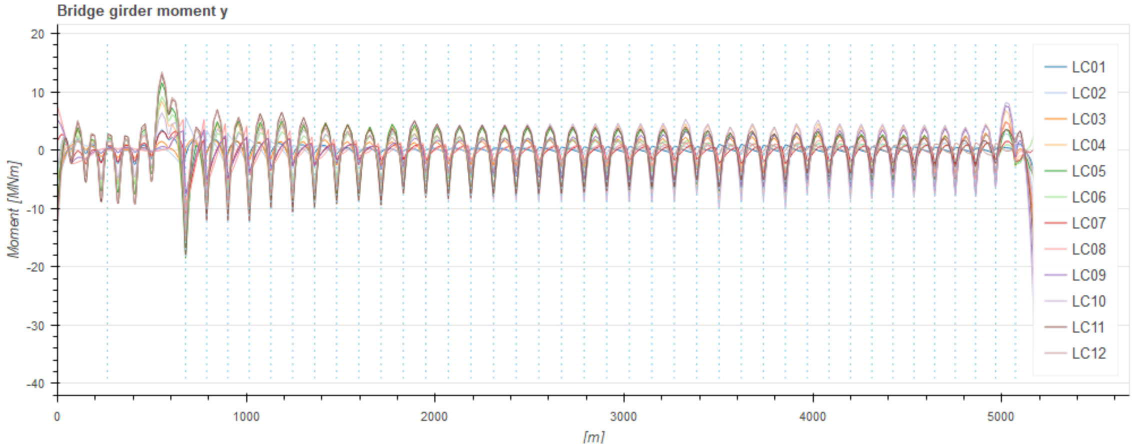


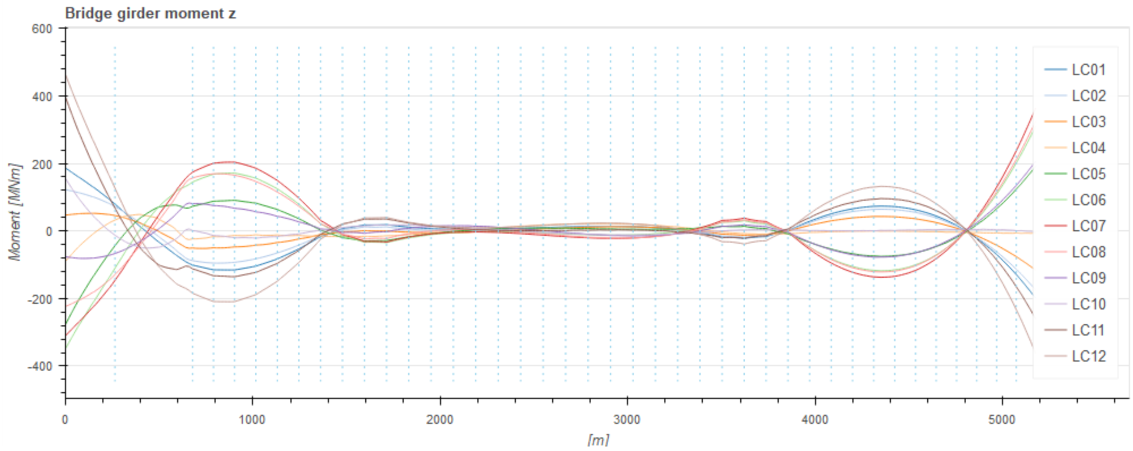




3.6.2 Mean response



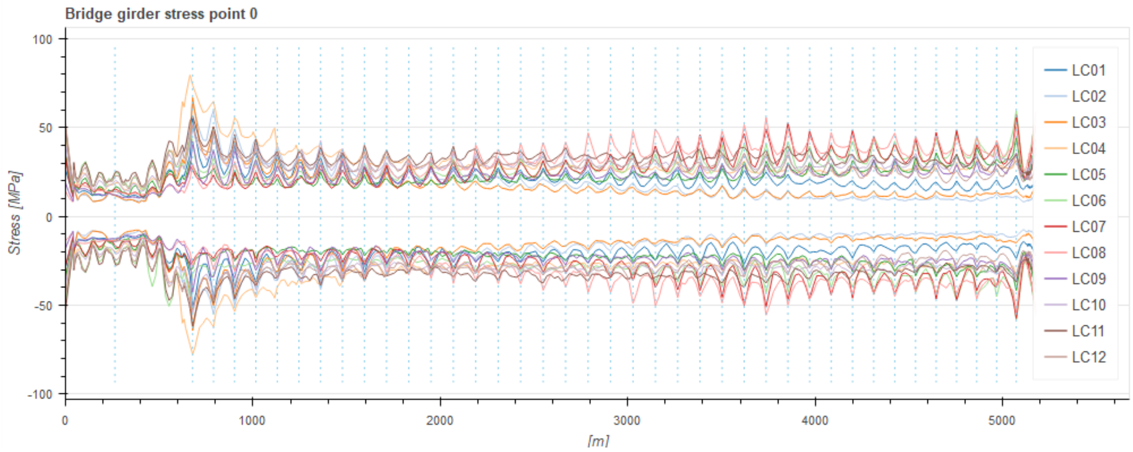


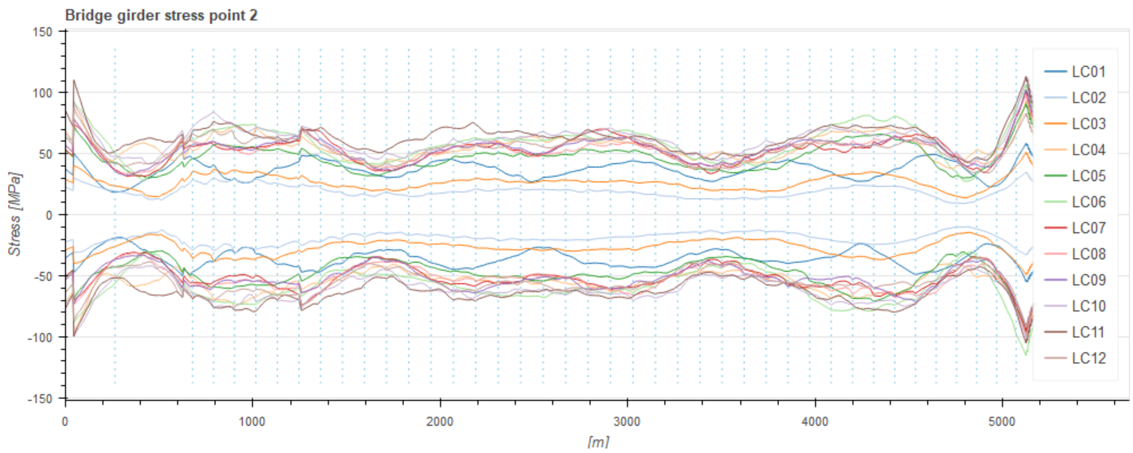


3.7 Stress

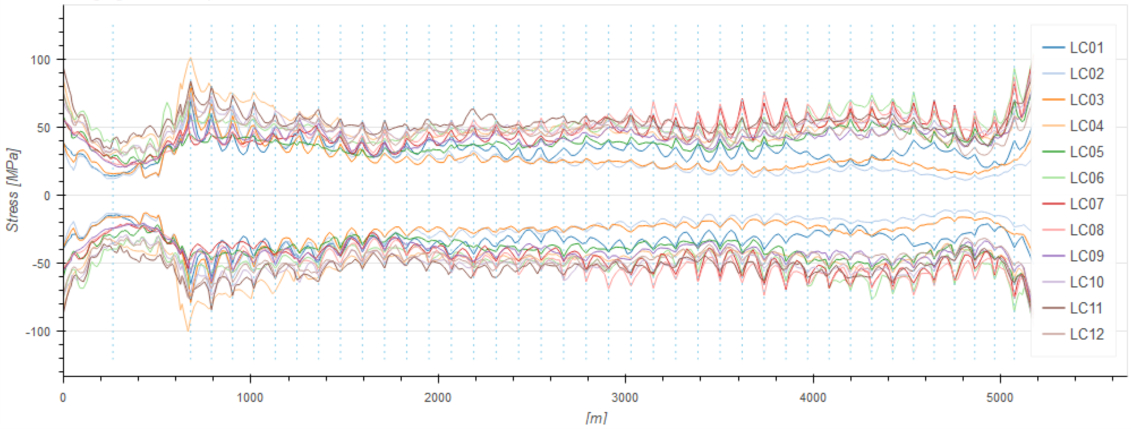
Stress points are numbered according to cross-sections presented in [2].

3.7.1 Max/min response

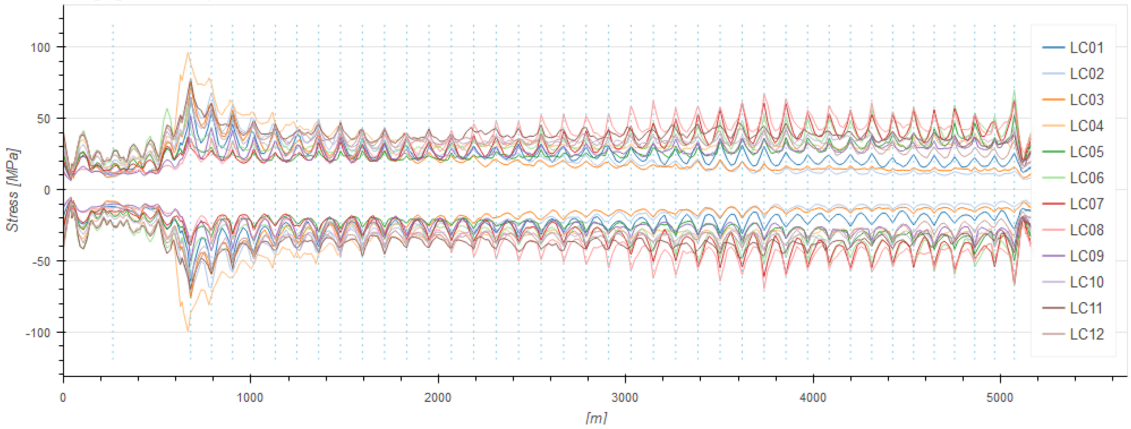




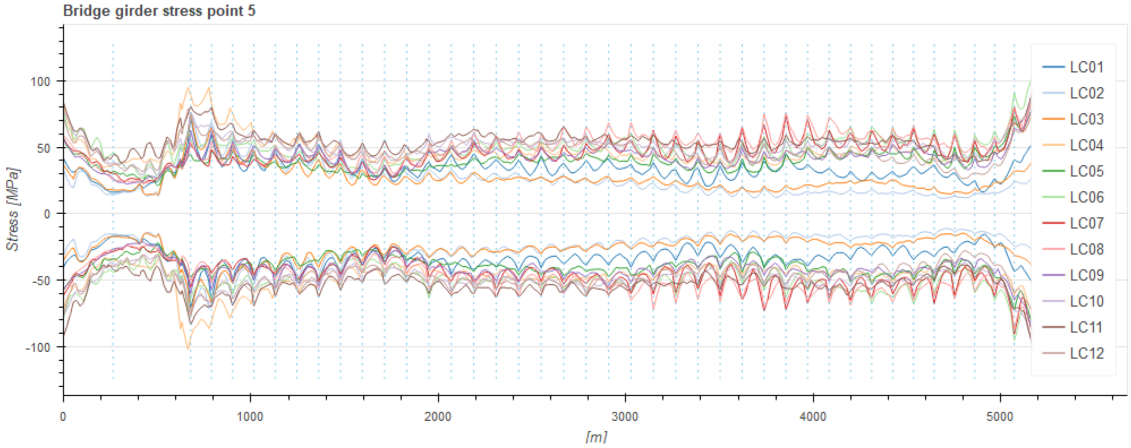
Bridge girder stress point 3

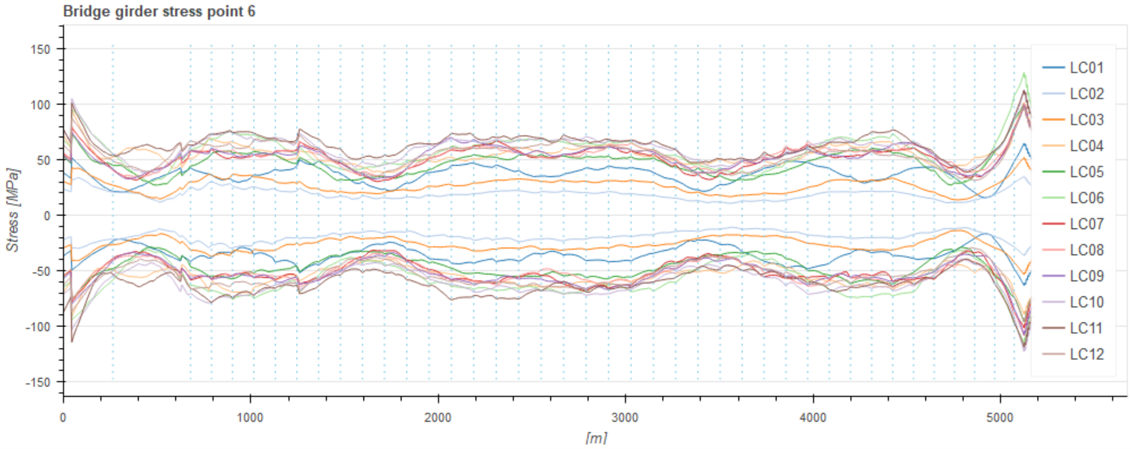


Bridge girder stress point 4



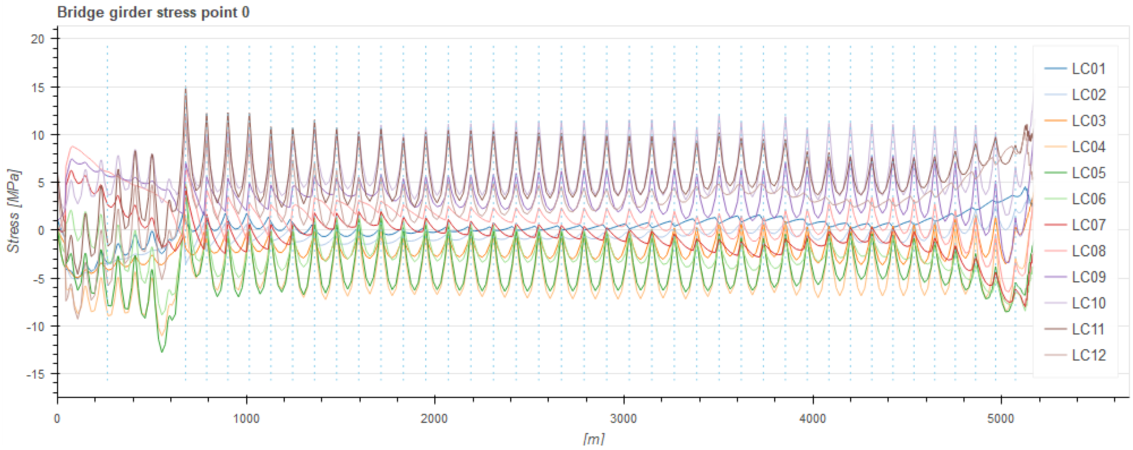
Bridge girder stress point 5

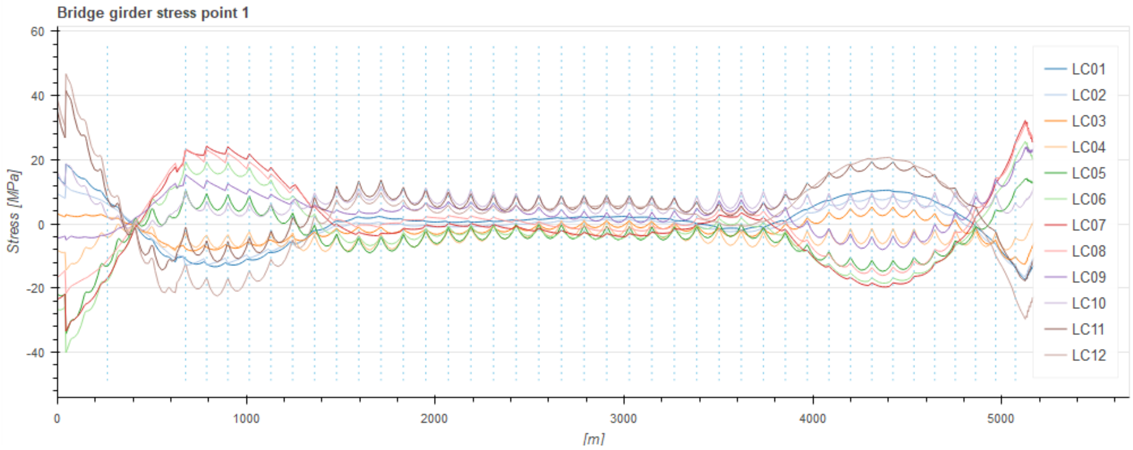


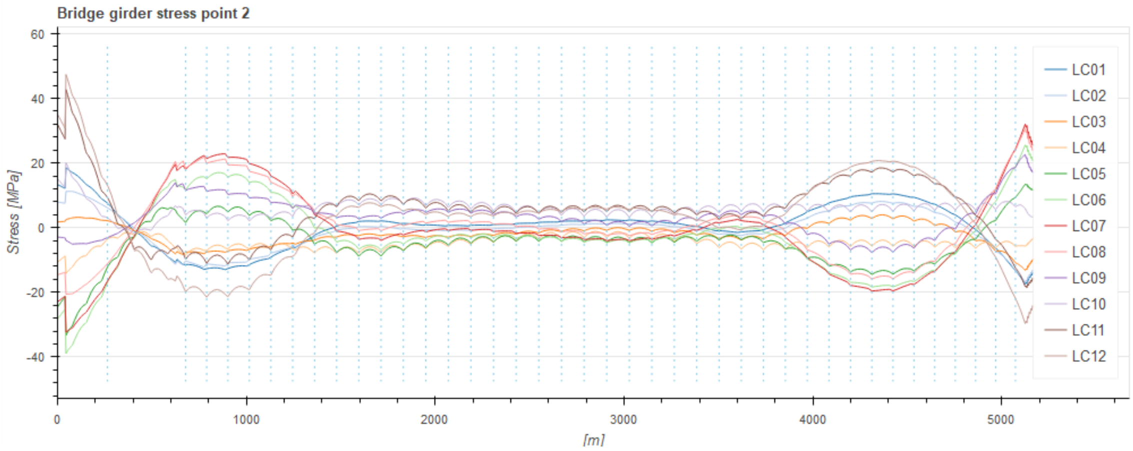

Bridge girder stress point 6
Stress [MPa]
[m]
LC01
LC02
LC03
LC04
LC05
LC06
LC07
LC08
LC09
LC10
LC11
LC12


Bridge girder stress point 7
Stress [MPa]
[m]
LC01
LC02
LC03
LC04
LC05
LC06
LC07
LC08
LC09
LC10
LC11
LC12

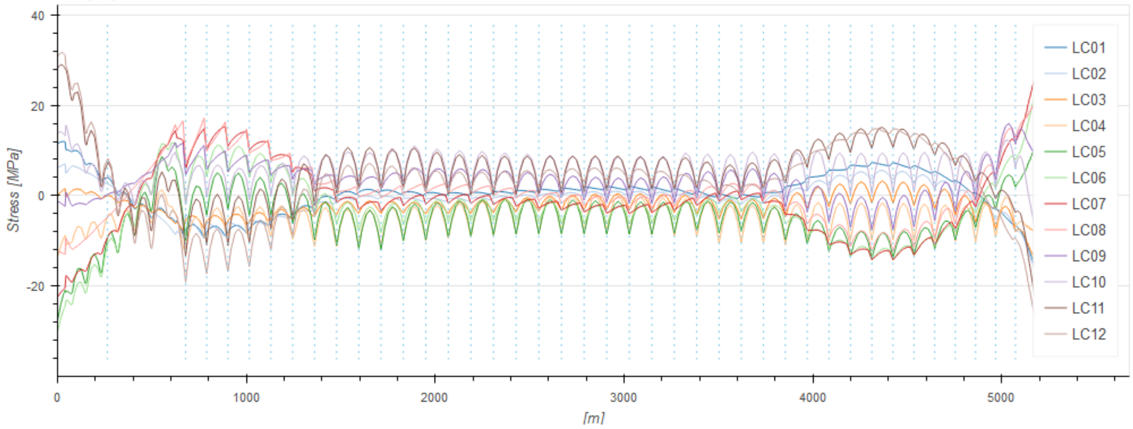
3.7.2 Mean response



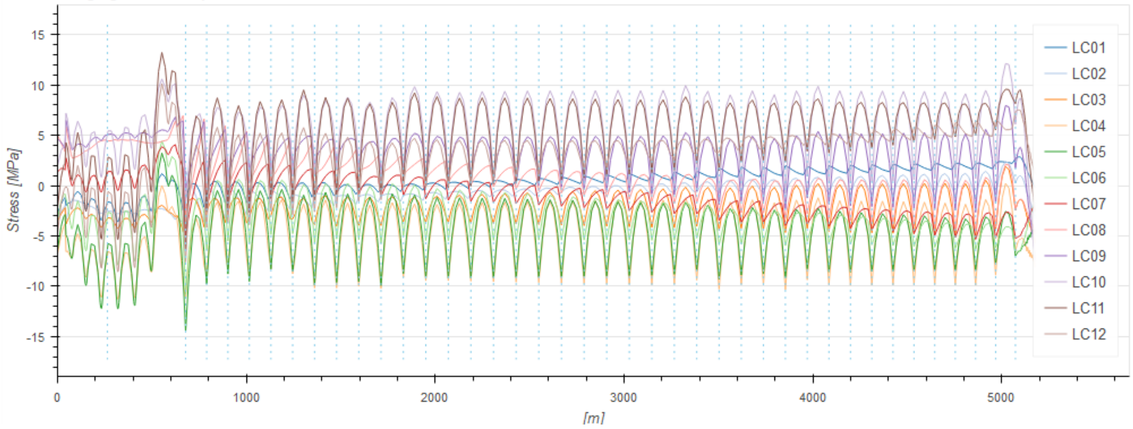




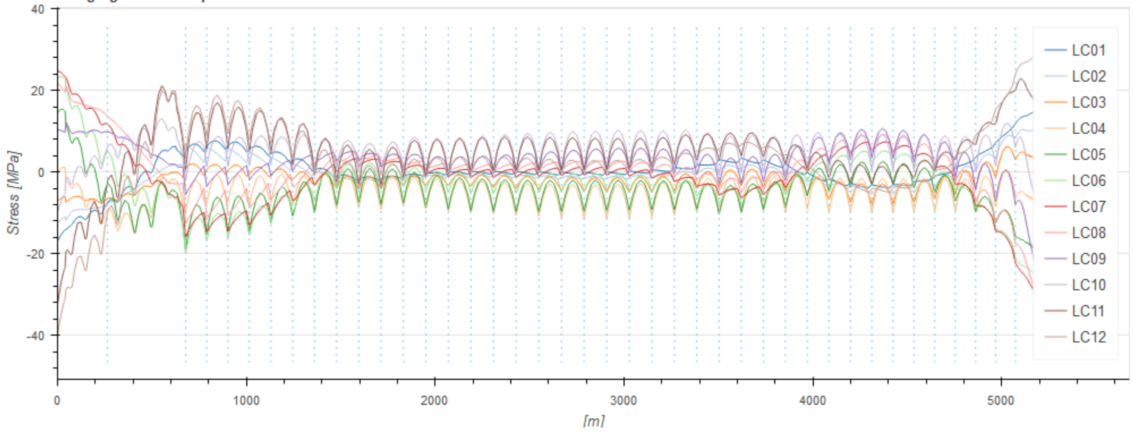
Bridge girder stress point 3

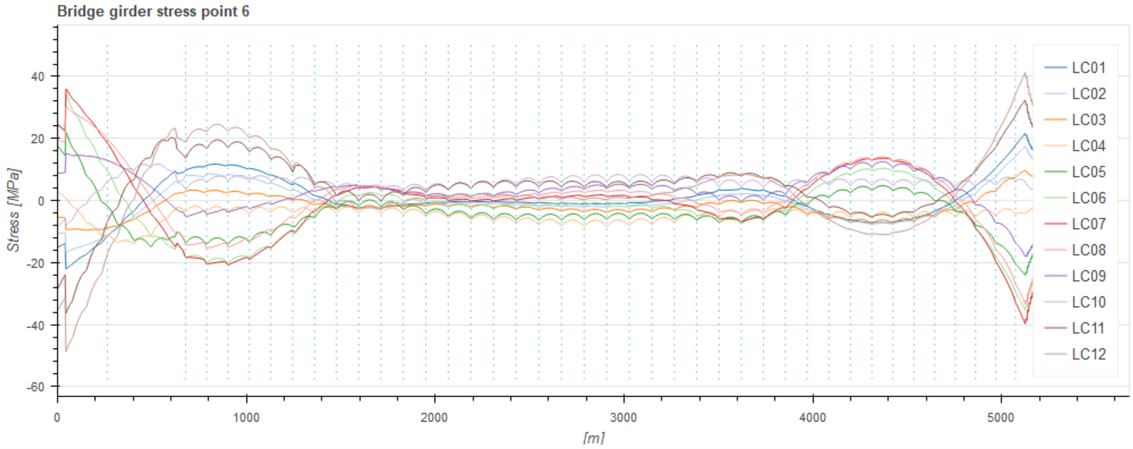


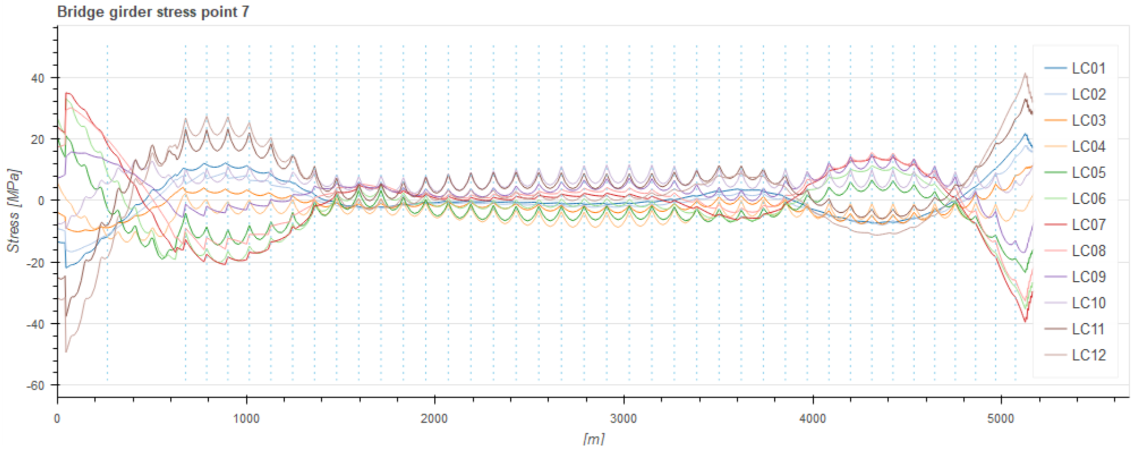
Bridge girder stress point 4



Bridge girder stress point 5




Bridge girder stress point 6
Stress [MPa]
[m]
LC01
LC02
LC03
LC04
LC05
LC06
LC07
LC08
LC09
LC10
LC11
LC12


Bridge girder stress point 7
Stress [MPa]
[m]
LC01
LC02
LC03
LC04
LC05
LC06
LC07
LC08
LC09
LC10
LC11
LC12

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