10 Enclosures

The following documents are enclosed with this report:

Enclosure 1 Detailed results for ship collision, K12_06

Enclosure 2 10205546-11-NOT-076 AMC status 2 - Plastic capacity of column, rev 0

Enclosure 3 Verification of fracture criterion

Concept development, floating bridge E39 Bjørnafjorden

Appendix J – Enclosure 1

Ship collision simulations for the Bjørnafjorden floating bridge Concept K12_06

Ship collision simulations for the Bjørnafjorden floating bridge Concept K12_06

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Contents

1 Introduction

This report summarizes the ship collision simulations performed on the Bjørnafjorden floating bridge on concept K12_06 (end-anchored floating bridge). A global beam model of the floating bridge was established in the explicit nonlinear FE software LS-DYNA SMP s r9.1. The model includes all large structural elements, and is balanced with gravity loads, buoyancy and pretension in the cables. Fixed boundary conditons are given to the bridge girder along with the lower node of tower legs and supporting columns in the back span. The rotational flexibility of the bridge abutments has no consequence for the dynamic behavior of the bridge during a ship collision.
Note that at the moment the pretension in the cables are initialized in the complete bridge system, resulting in a force that pulls the floating bridge towards the cable-stayed bridge due to the pretension. Hence, the initial configuration of the bridge is somewhat different from the actual conditon.
Pontoons are included as rigid bodies with buoyancy applied as a draught-dependent load. Hydrostatic stiffness in roll and pitch are included as linear springs using the I_{44} and I_{55} spring stiffnesses as obtained from Wamit/Orcaflex simulations. Viscous drag damping in surge and sway is included as velocity-dependent variables in nonlinear discrete dampers. Mooring stiffness is included as nonlinear springs, whereas mooring damping is included as a linear damping with coefficient 1 $MN/m/s$ for each anchor group. This is likely below the actual values for the bridge mooring systems [1], and on the conservative side.
The local interaction between a deformable ship structure and the deformable bridge component was modelled with a nonlinear spring (Figure 1.1) calibrated to the force-indentation curves found from integrated analysis in LS-DYNA as presented by [2]. The spring allows release of the vessel after impact due to elastic rebound, which for local column forces may be non-conservative. However, the global bridge girder response is adequatly captured (see [3] for details).

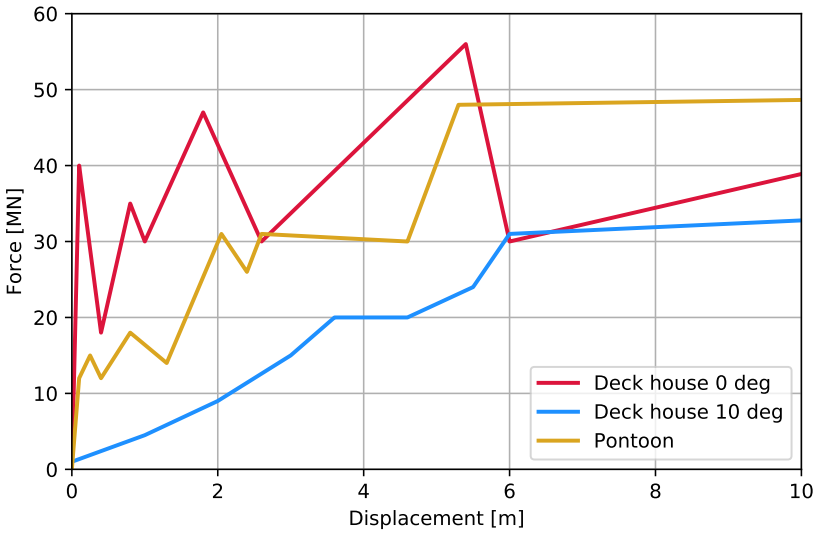

Figure 1.1: Applied nonlinear spring stiffness for the selected collision scenarios

Two sets of simulations were performed; impact from a ship bow to a pontoon and impact from a deckhouse structure to the bridge girder. A range of impact locations and heading relative to the bridge transverse axis were defined. The energies (initial mass and velocity along with a 10% added mass) were defined as in Table 1. This report lists the main results.

Table 1: Revised ship collision scenarios as pr. updated design bases in Jan. 2019

CC 125m	**Displacement**	**Velocity**	**LOA**	**Energy**	
				w.o. added mass	w. added mass
Element	[tonne]	[m/s]	[m]	[MJ]	[MJ]
Bridge girder North (of Axis 23)	14855	5.8	139	250	275
Bridge girder South (of Axis 23)	21123	6.2	208	406	447
Pontoon, Axis 3	14565	5.7	140	237	261
Pontoon, Axis 4-5	13878	5.6	130	218	240
Pontoon, Axis 6-23	13259	5.5	130	201	221
Pontoon, Axis 24-35	10649	5.1	120	138	152

2 Summary

2.1 Ship bow - pontoon collision

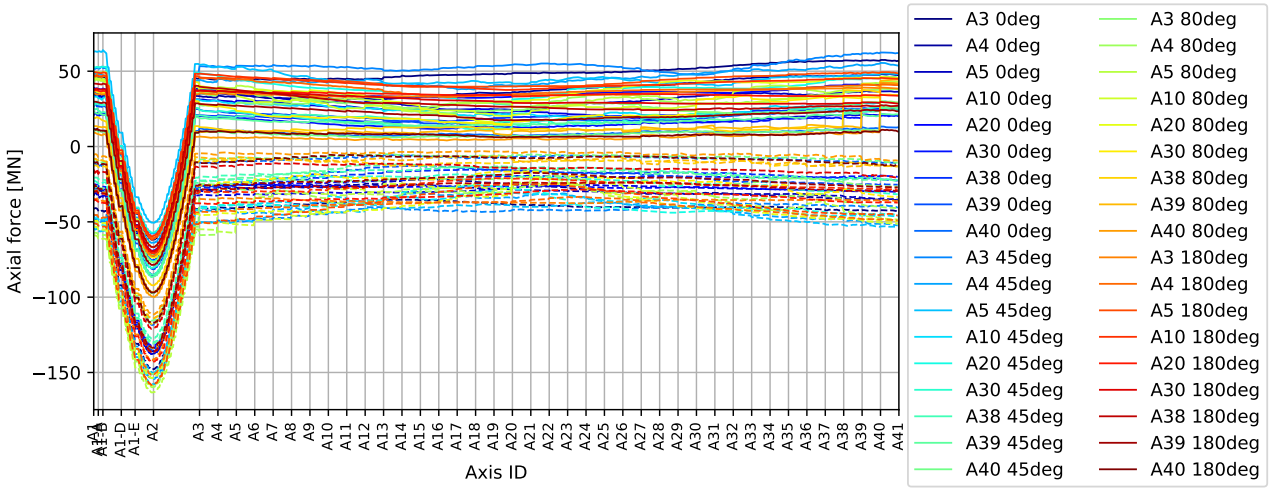

Figure 2.1: Bridgegirder : Axial force [MN]

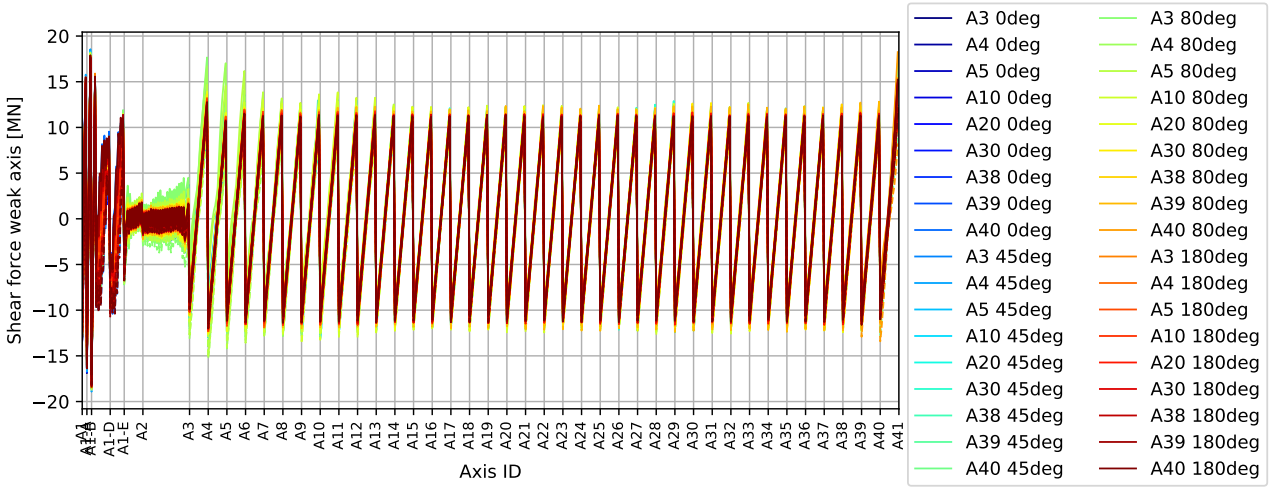

Figure 2.2: Bridgegirder : Shear force weak axis [MN]

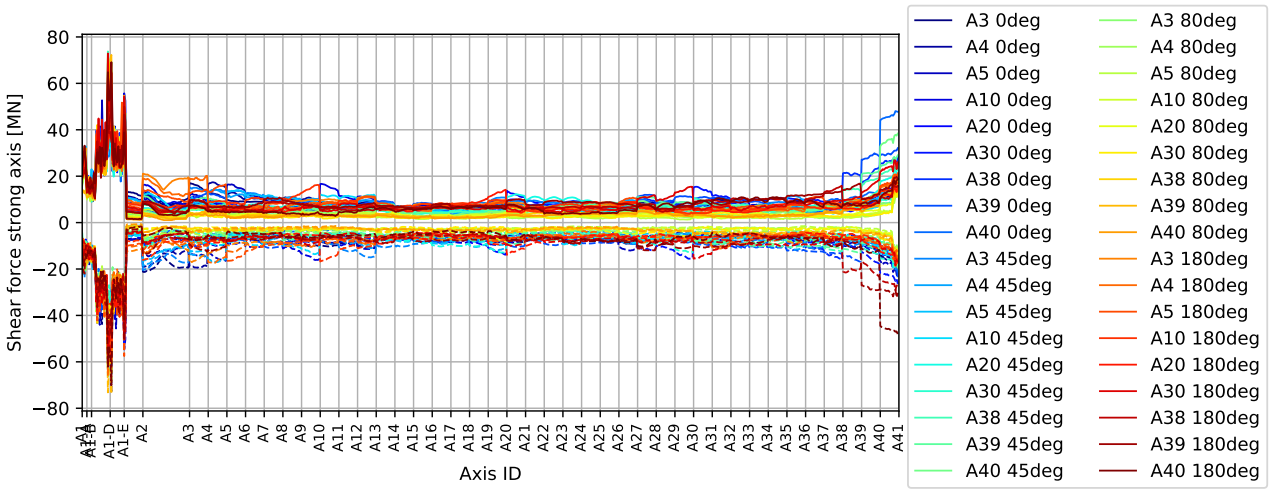

Figure 2.3: Bridgegirder : Shear force strong axis [MN]

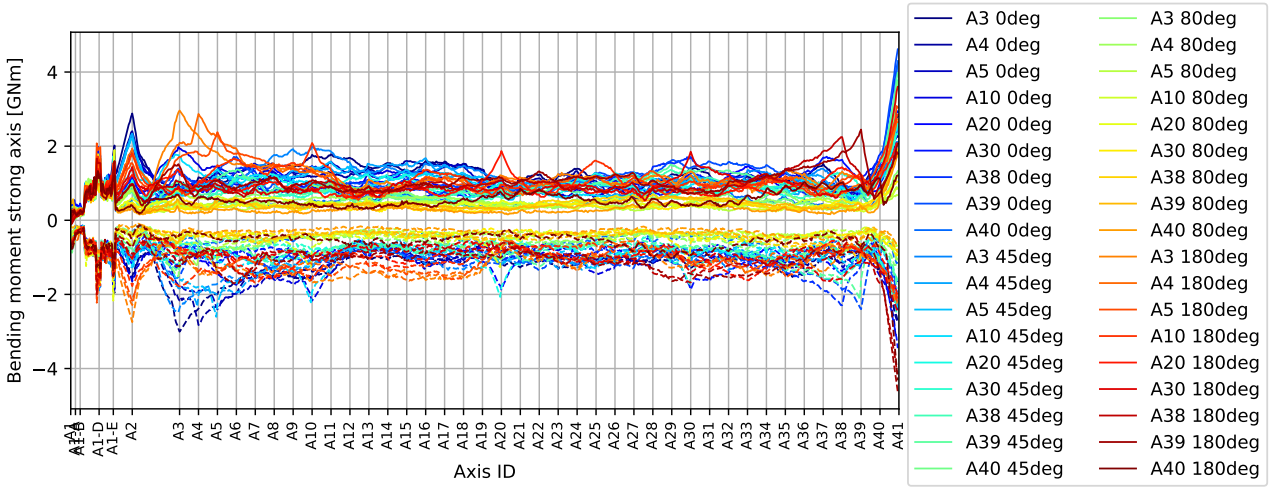

Figure 2.4: Bridgegirder : Bending moment strong axis [GNm]

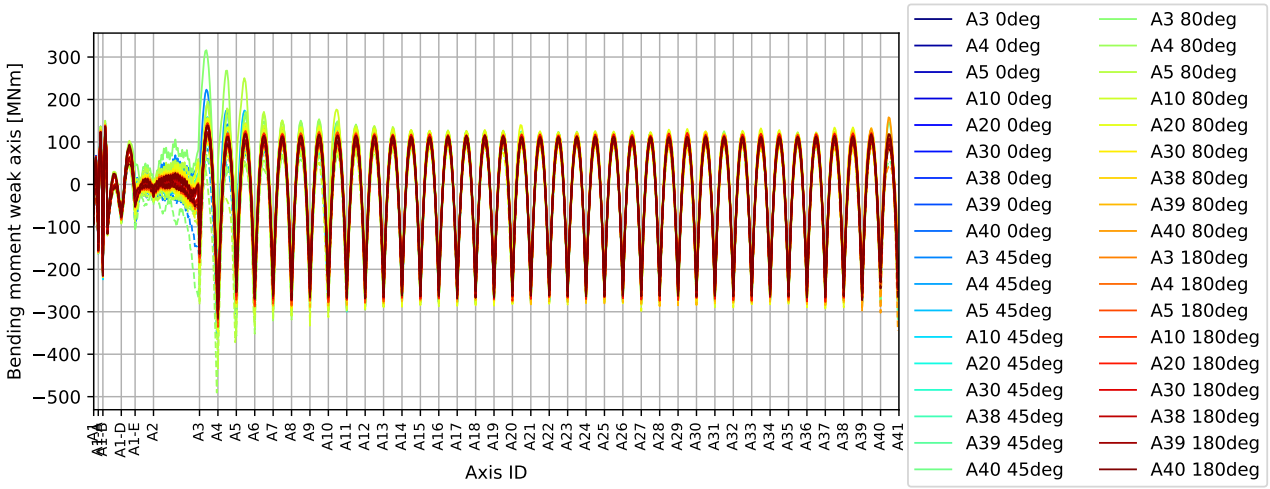

Figure 2.5: Bridgegirder : Bending moment weak axis [MNm]

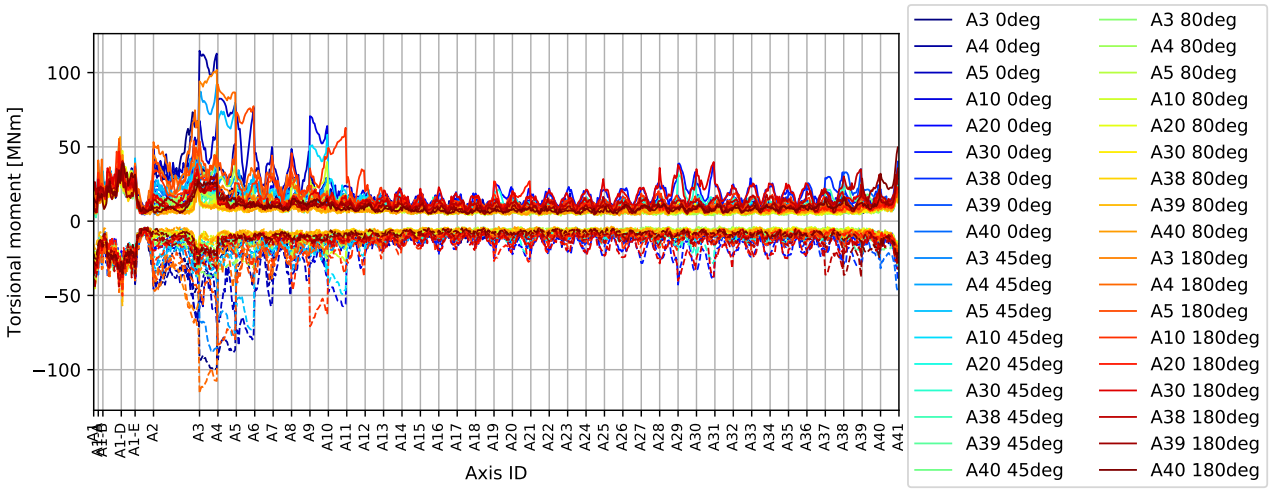

Figure 2.6: Bridgegirder : Torsional moment [MNm]

2.2 Ship deck house - bridge girder collision

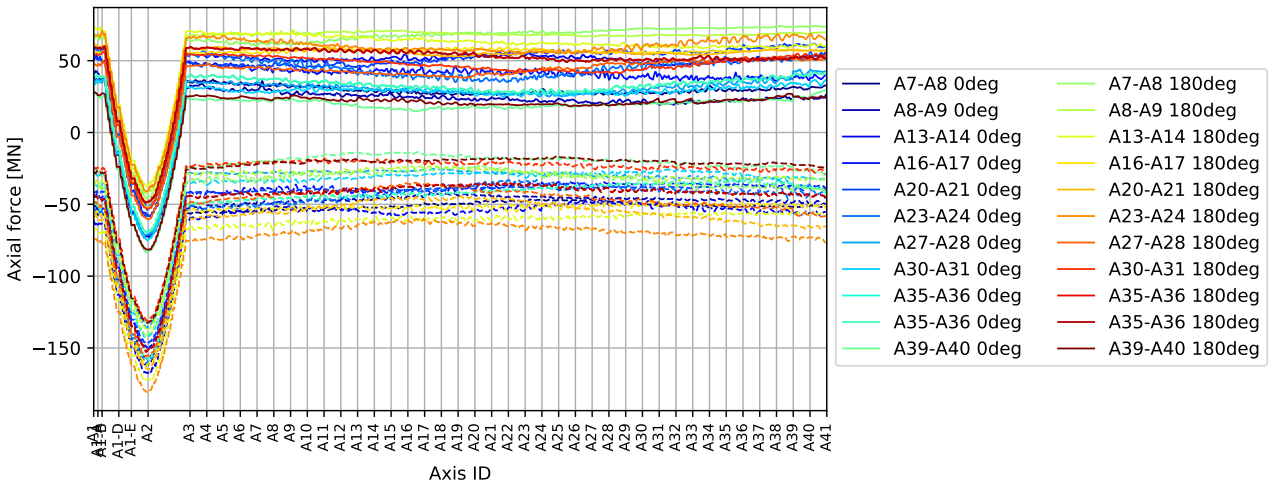

Figure 2.7: Bridgegirder : Axial force [MN]

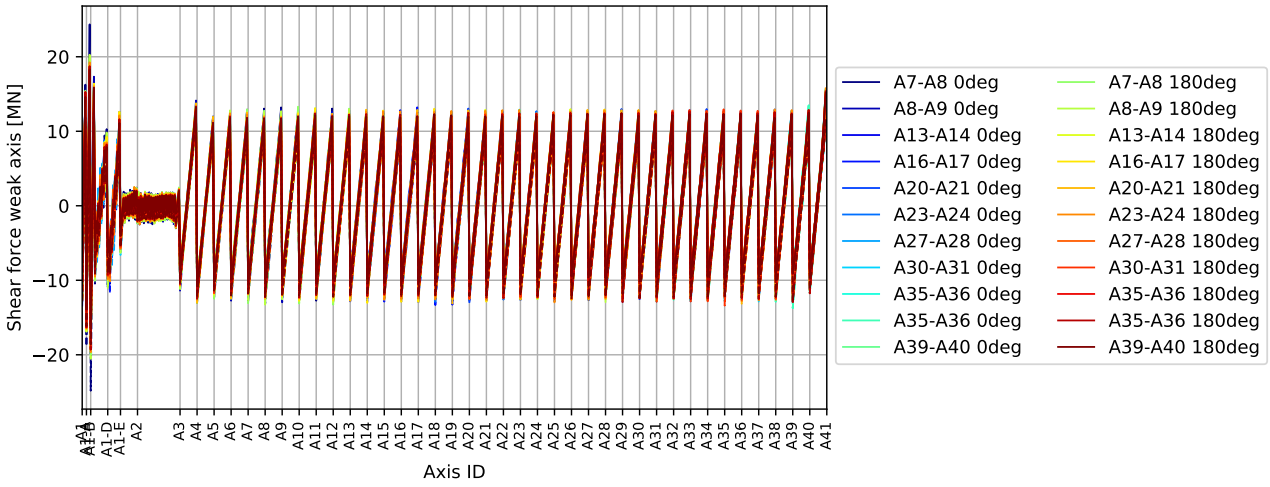

Figure 2.8: Bridgegirder : Shear force weak axis [MN]

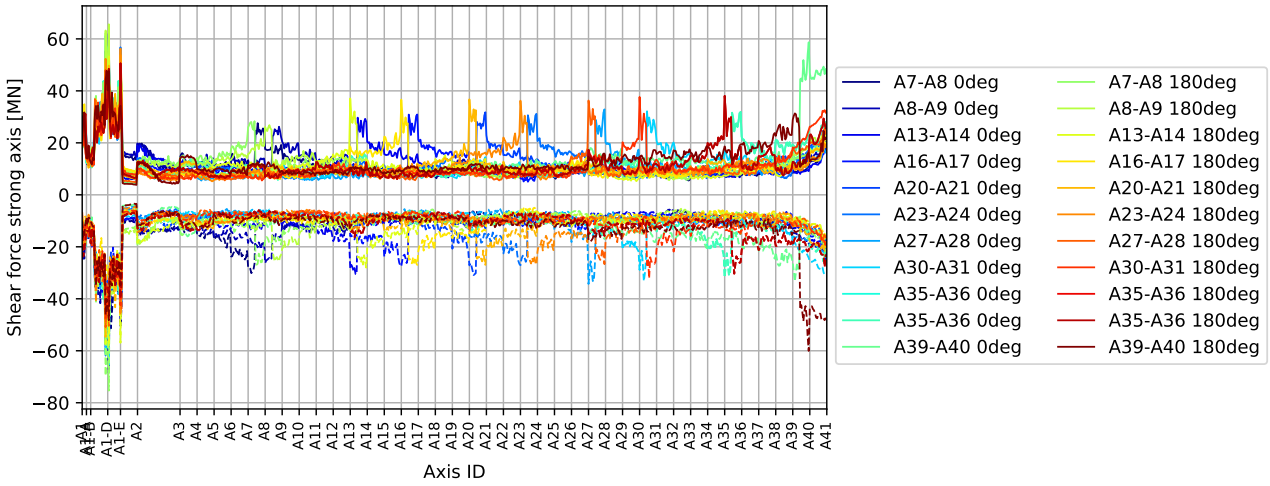

Figure 2.9: Bridgegirder : Shear force strong axis [MN]

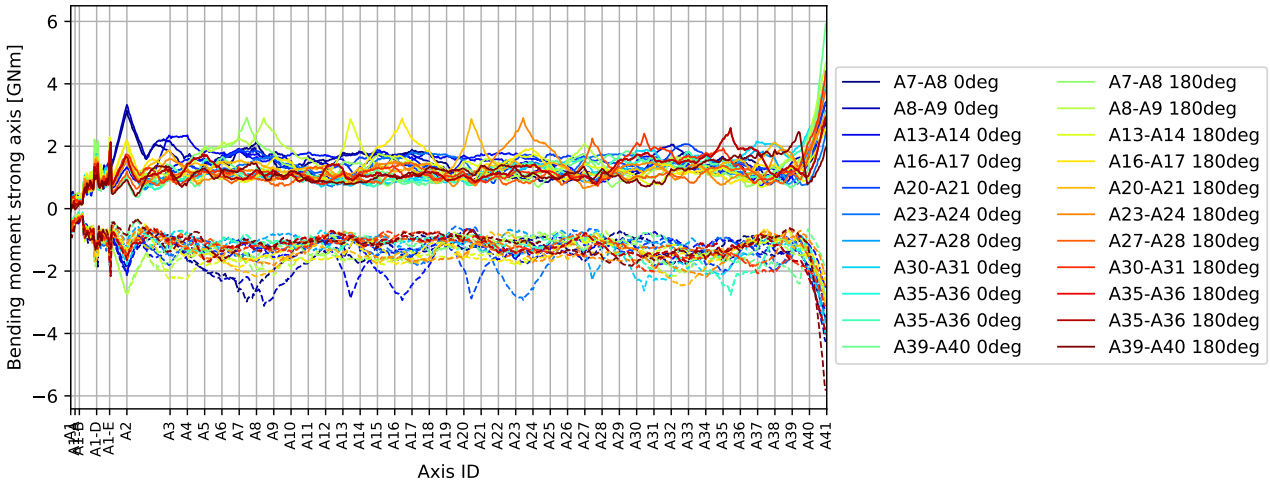

Figure 2.10: Bridgegirder : Bending moment strong axis [GNm]

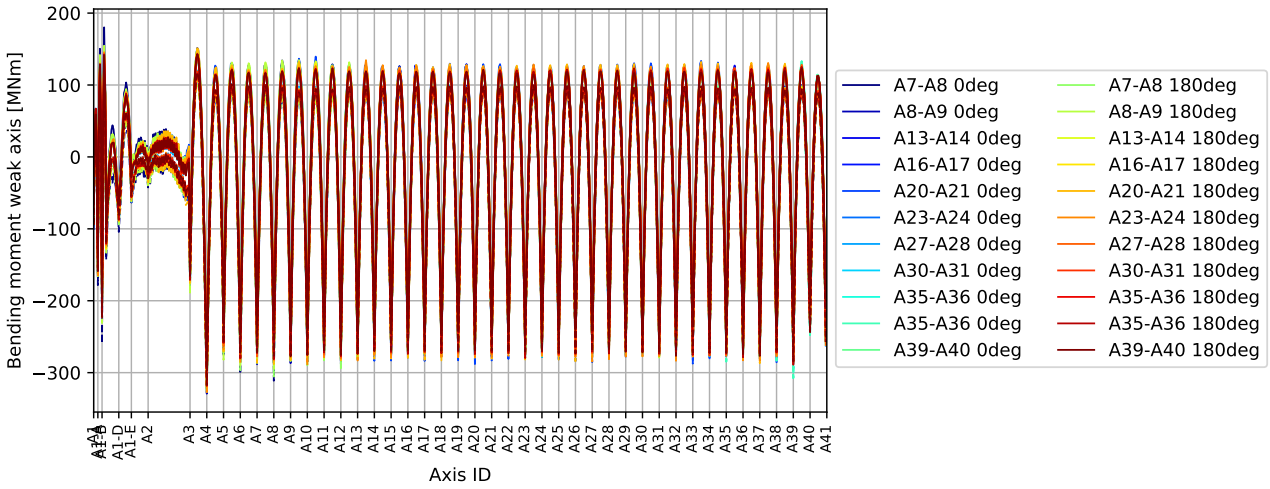

Figure 2.11: Bridgegirder : Bending moment weak axis [MNm]

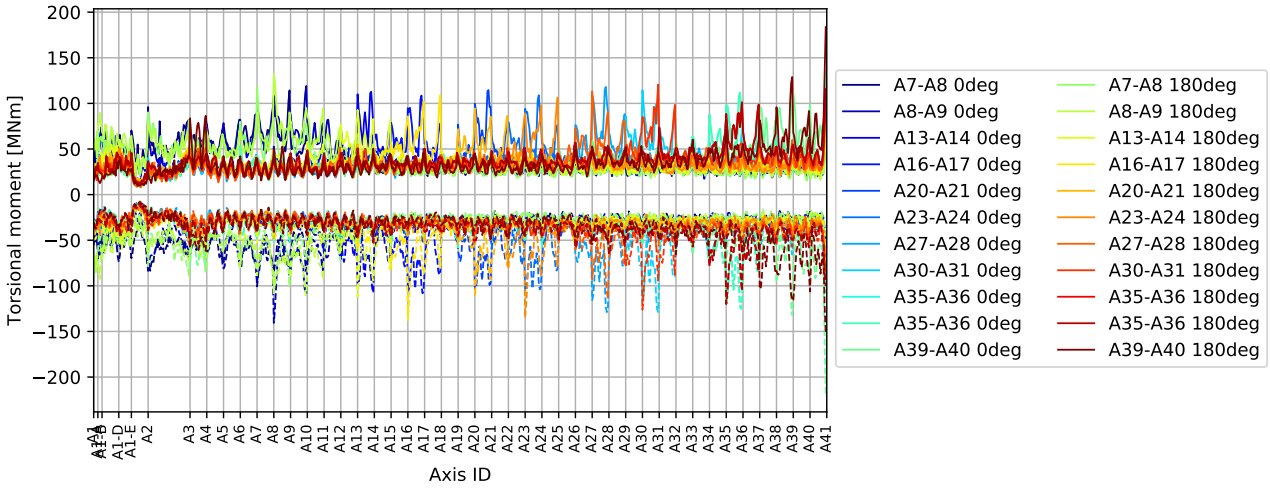

Figure 2.12: Bridgegirder : Torsional moment [MNm]

3 Detailed results : Ship bow - pontoon collision

3.1 PontoonA3 0deg

3.1.1 Overall response

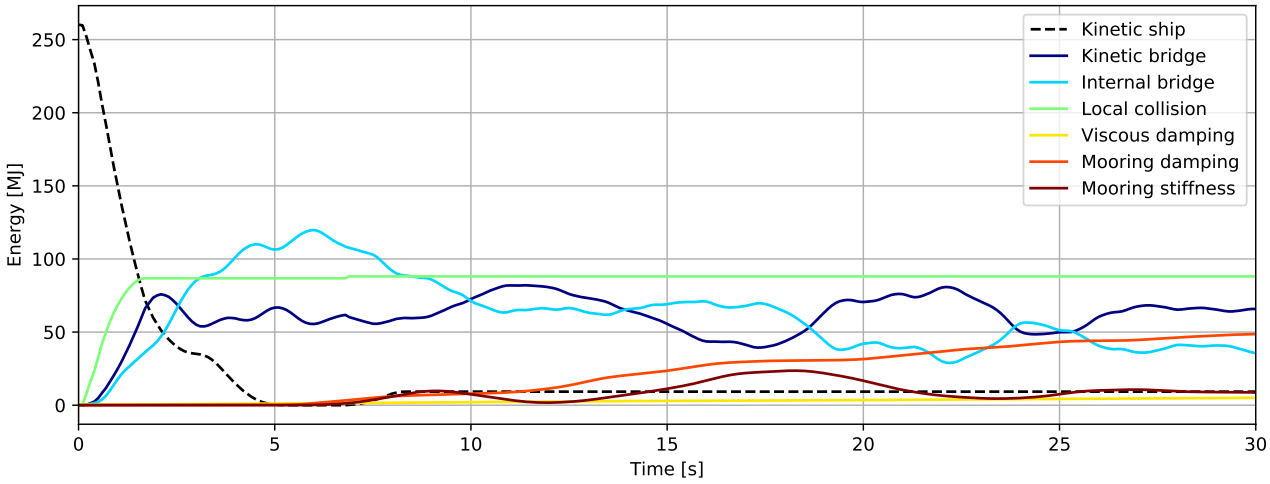

Figure 3.1: Energy [MJ] - initial phase

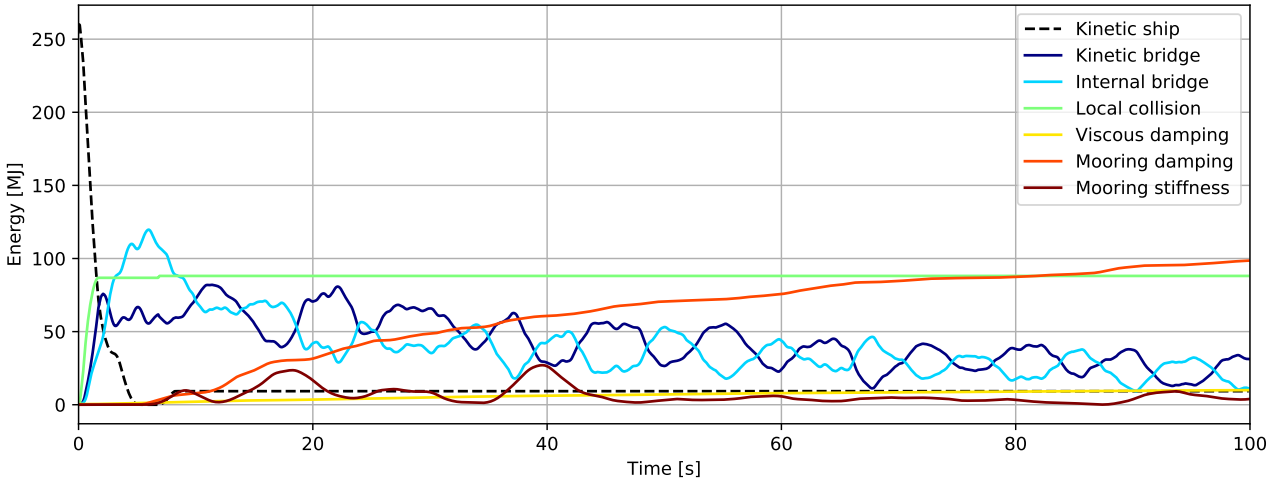

Figure 3.2: Energy [MJ]

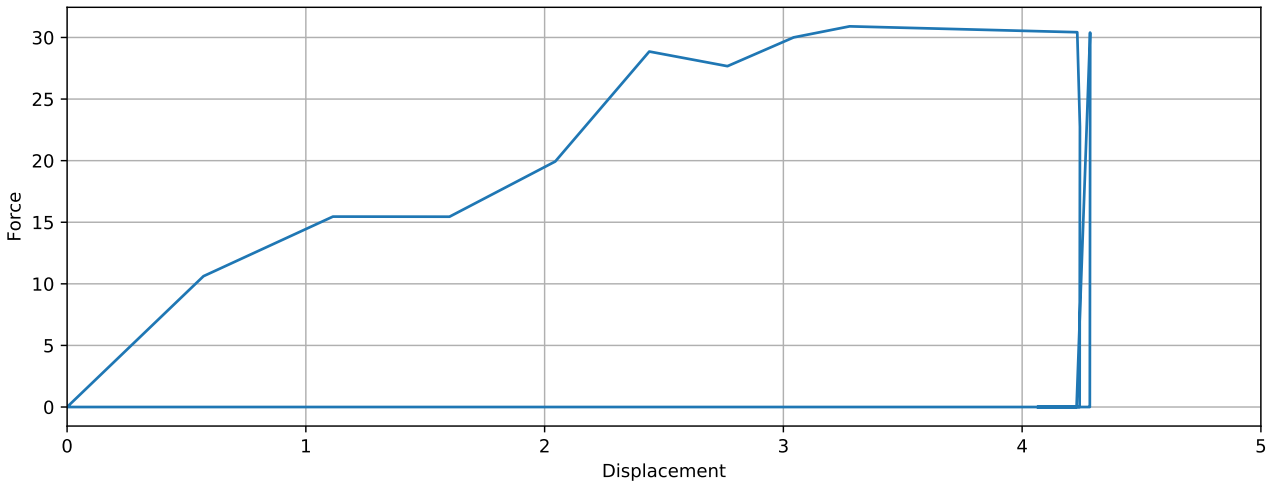

Figure 3.3: Simulated local collision force-displacement

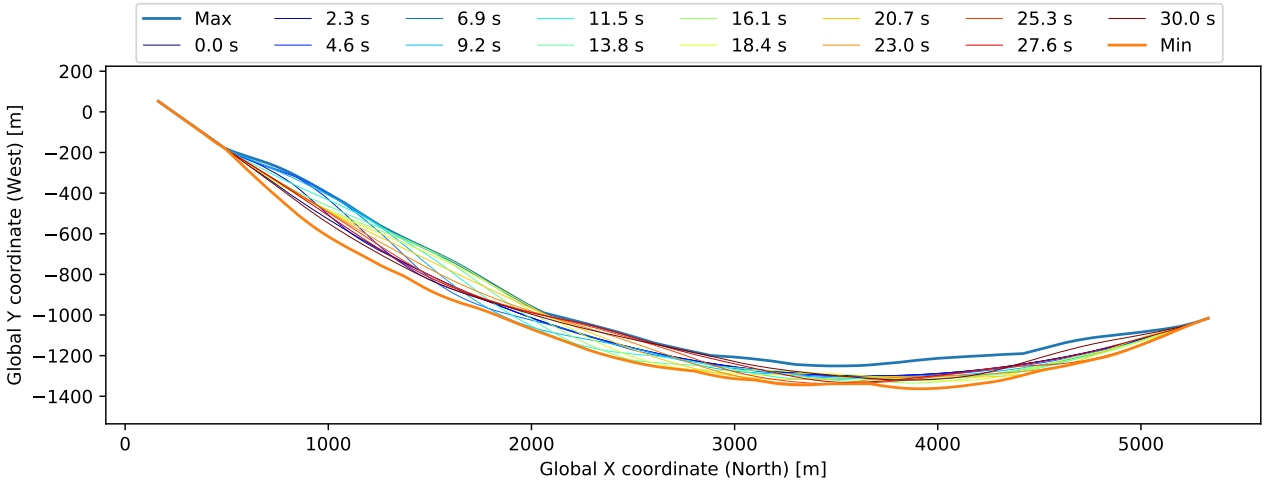

Figure 3.4: Bridgegirder deflection (10x displacment scaling)

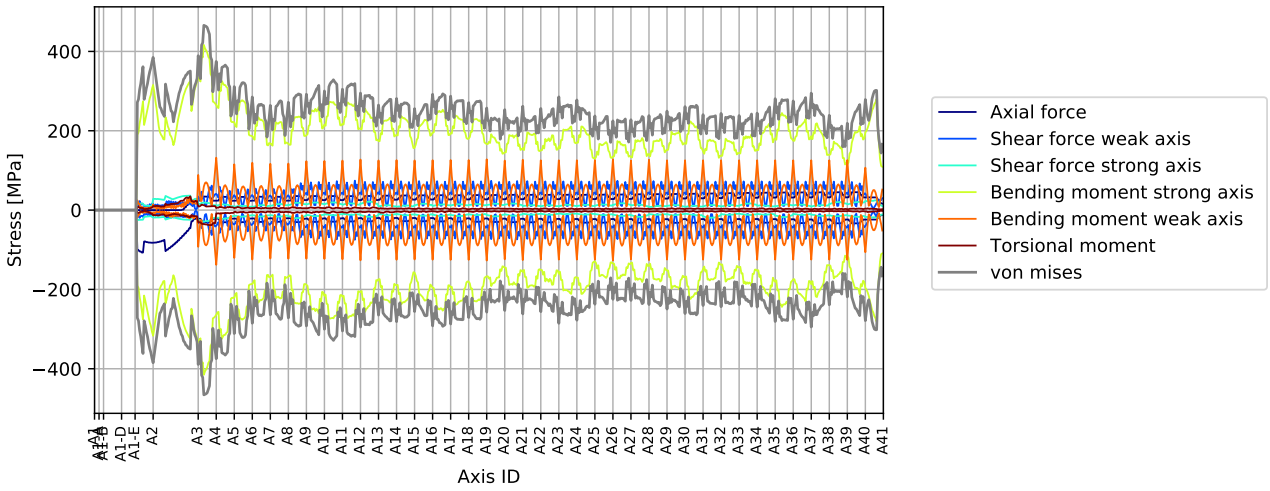

Figure 3.5: Stress envelope from all force components

3.1.2 Envelope plots

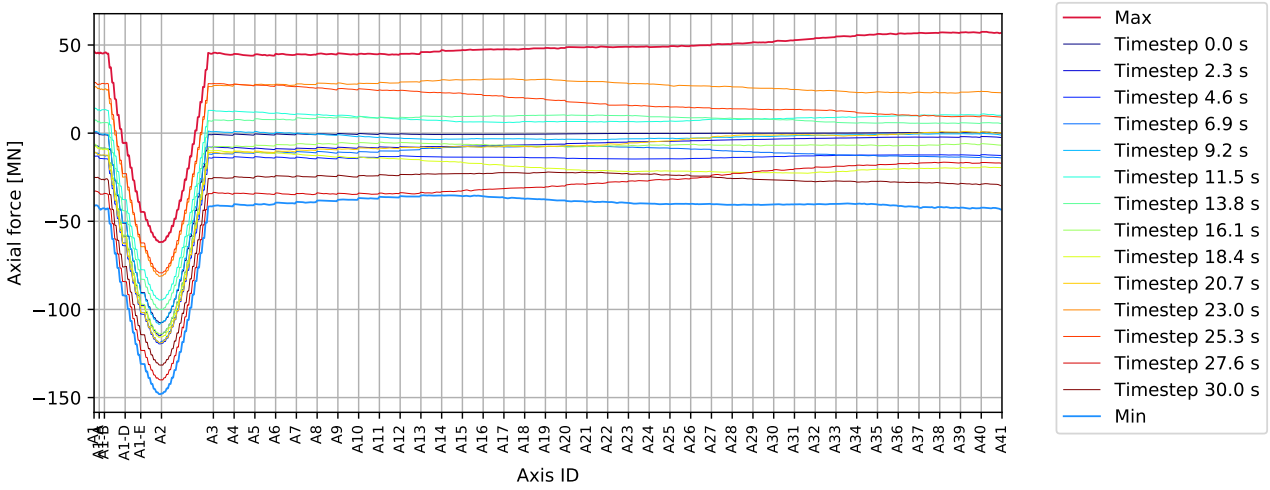

Figure 3.6: P A3 0deg - bridgegirder : Axial force [MN]

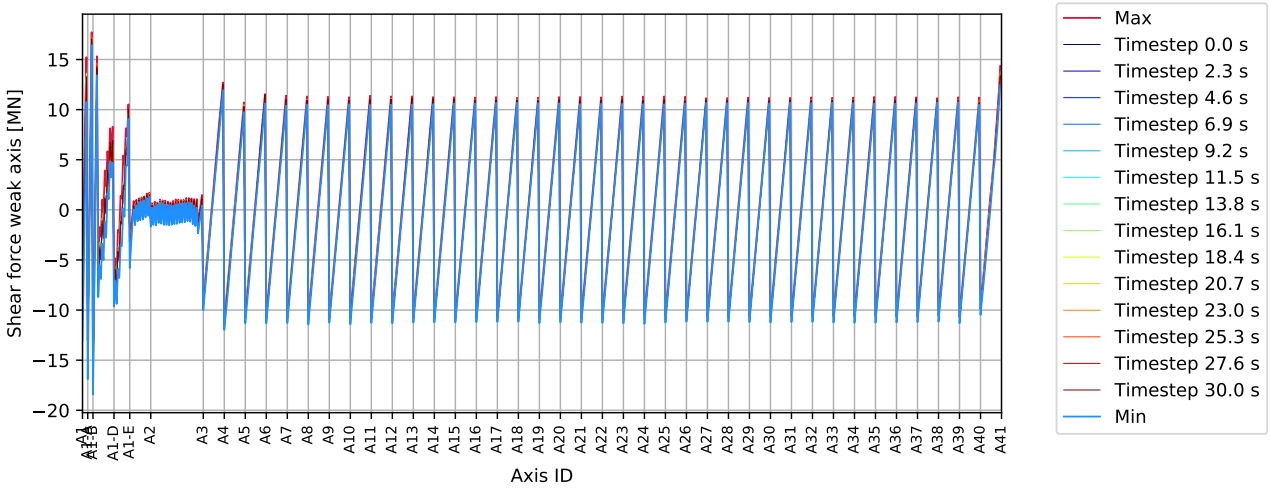

Figure 3.7: P A3 0deg - bridgegirder : Shear force weak axis [MN]

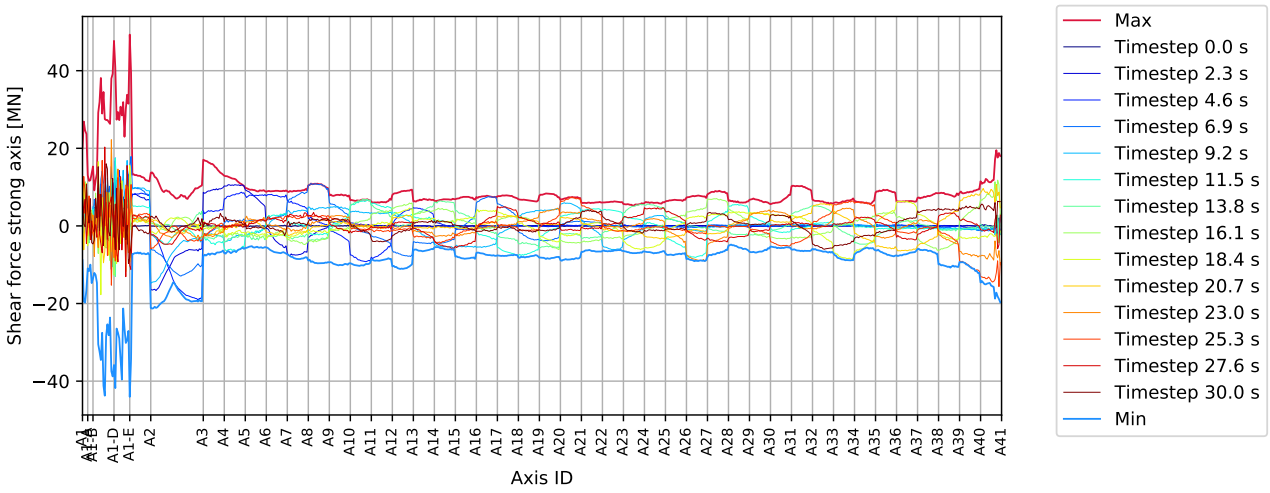

Figure 3.8: P A3 0deg - bridgegirder : Shear force strong axis [MN]

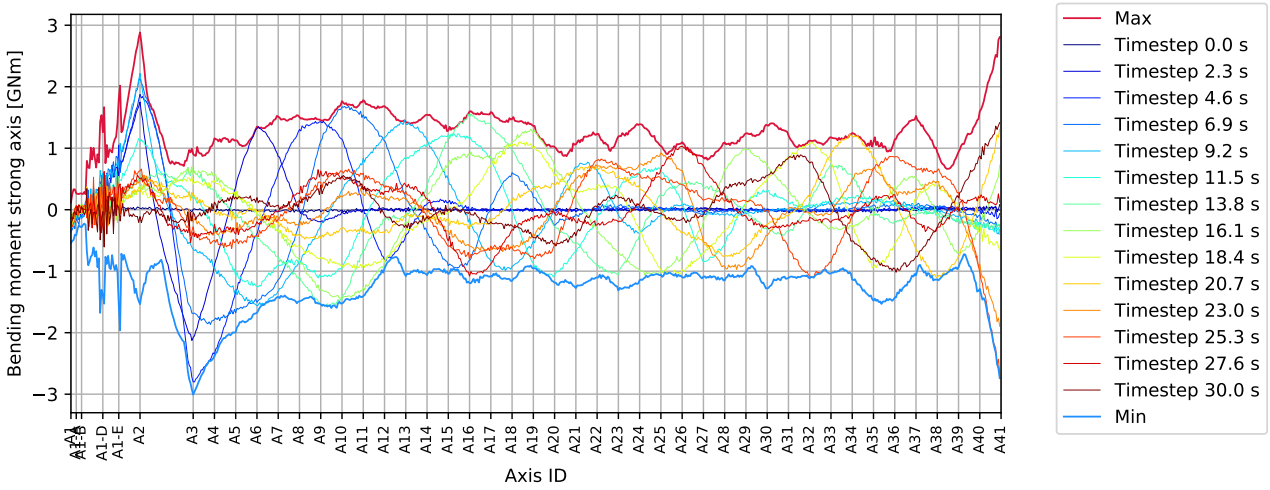

Figure 3.9: P A3 0deg - bridgegirder : Bending moment strong axis [GNm]

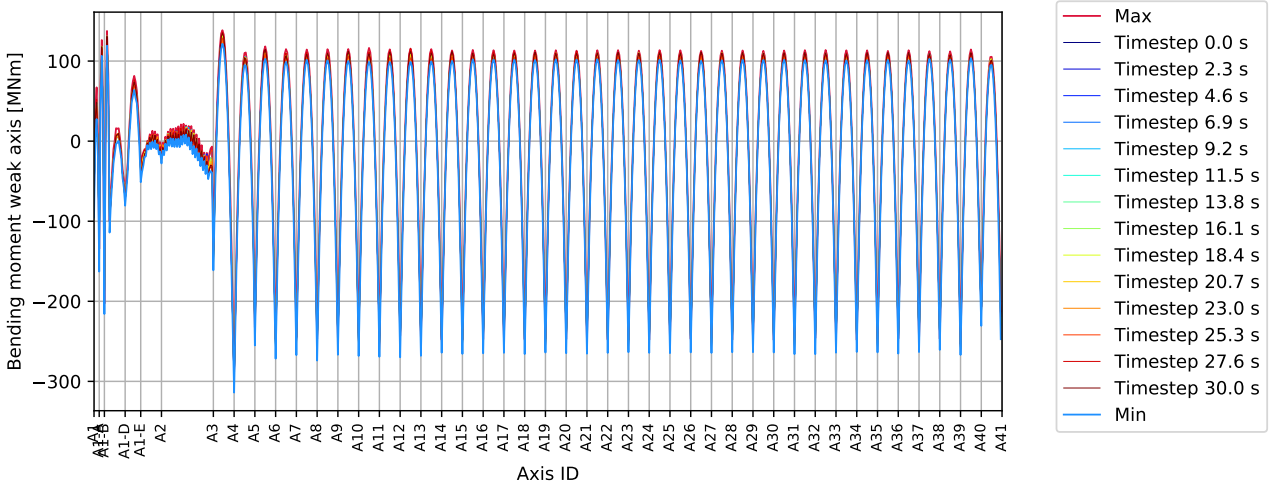

Figure 3.10: P A3 0deg - bridgegirder : Bending moment weak axis [MNm]

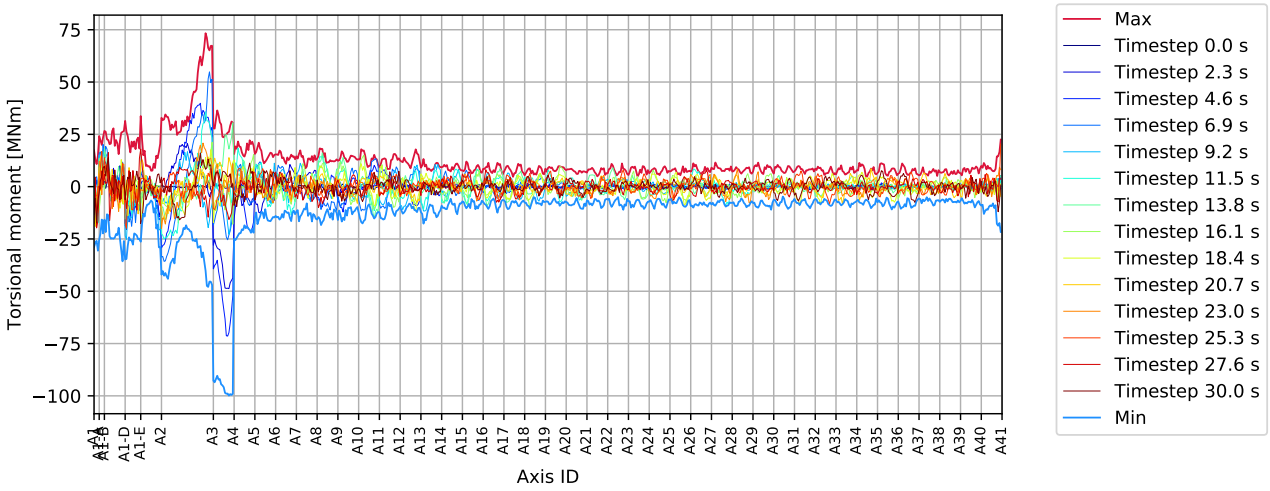

Figure 3.11: P A3 0deg - bridgegirder : Torsional moment [MNm]

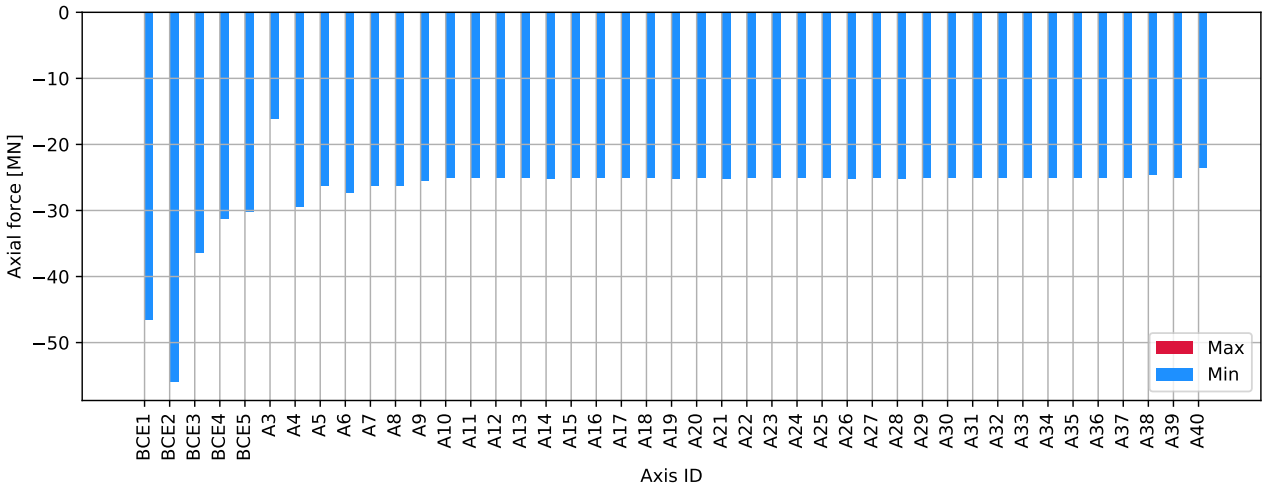

Figure 3.12: P A3 0deg - columns bottom : Axial force [MN]

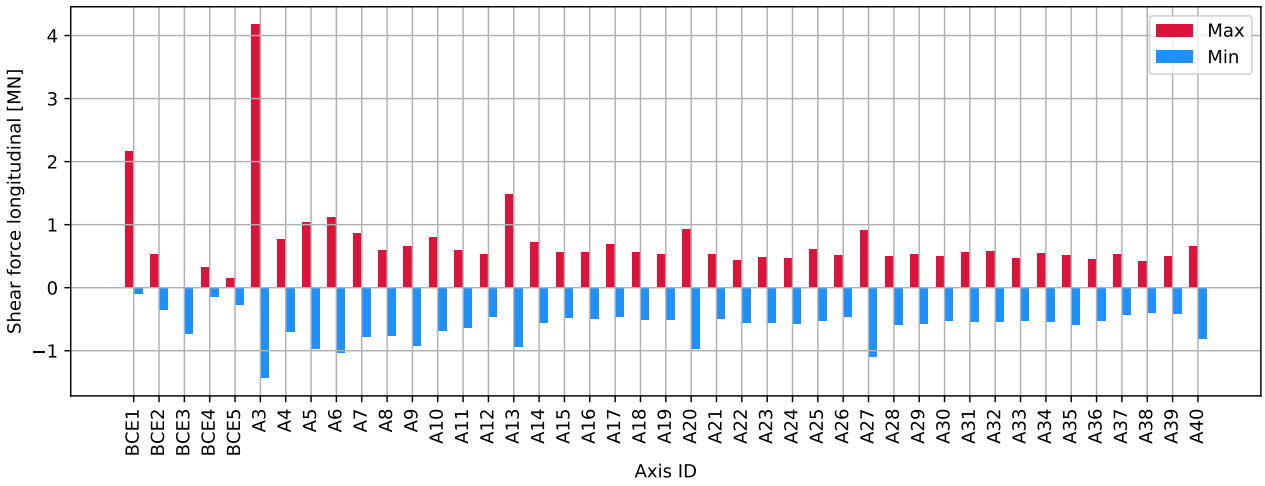

Figure 3.13: P A3 0deg - columns bottom : Shear force longitudinal [MN]

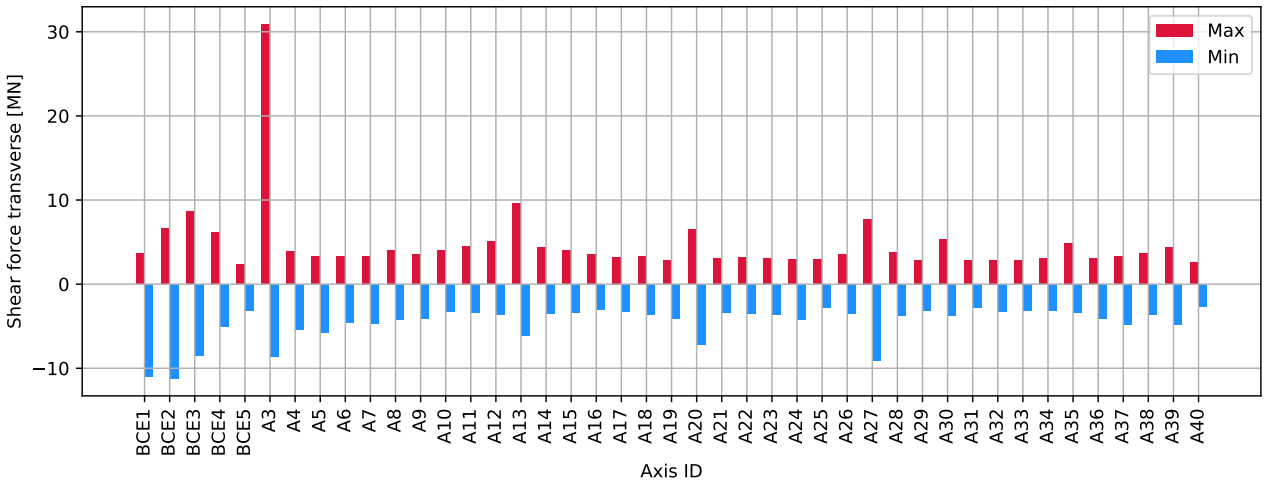

Figure 3.14: P A3 0deg - columns bottom : Shear force transverse [MN]

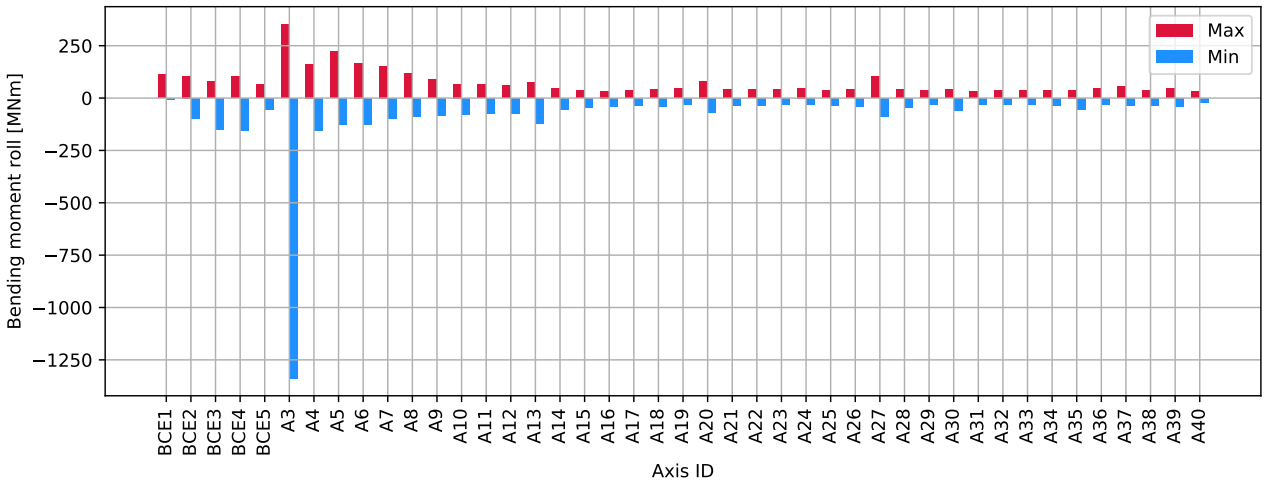

Figure 3.15: P A3 0deg - columns bottom : Bending moment roll [MNm]

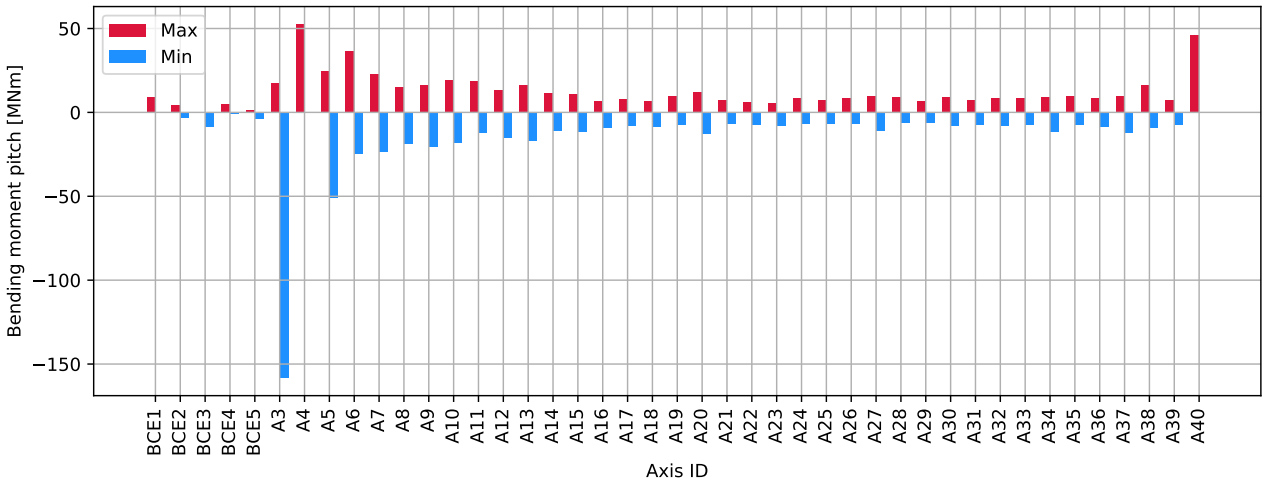

Figure 3.16: P A3 0deg - columns bottom : Bending moment pitch [MNm]

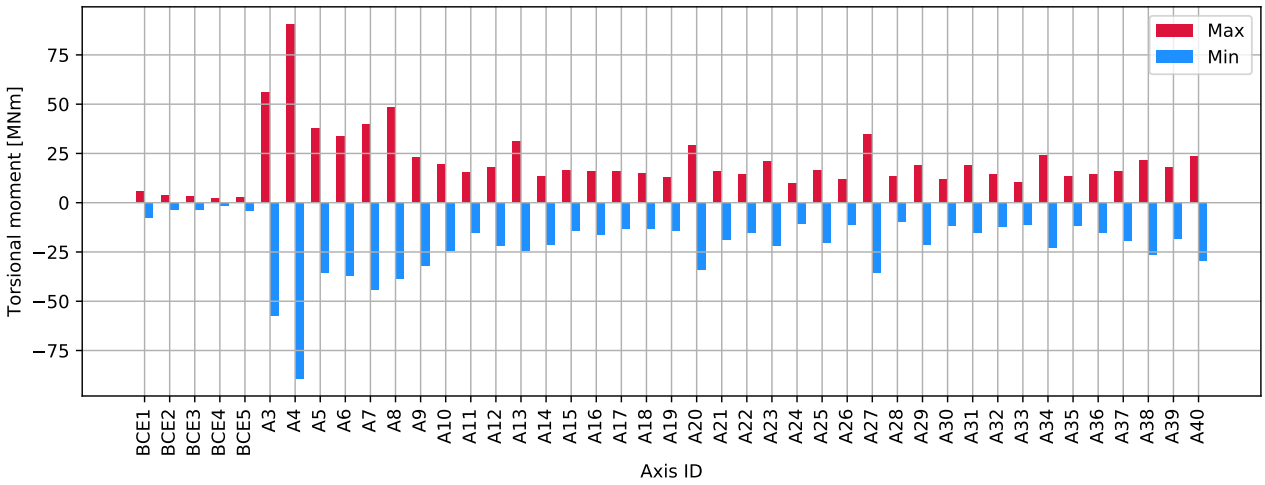

Figure 3.17: P A3 0deg - columns bottom : Torsional moment [MNm]

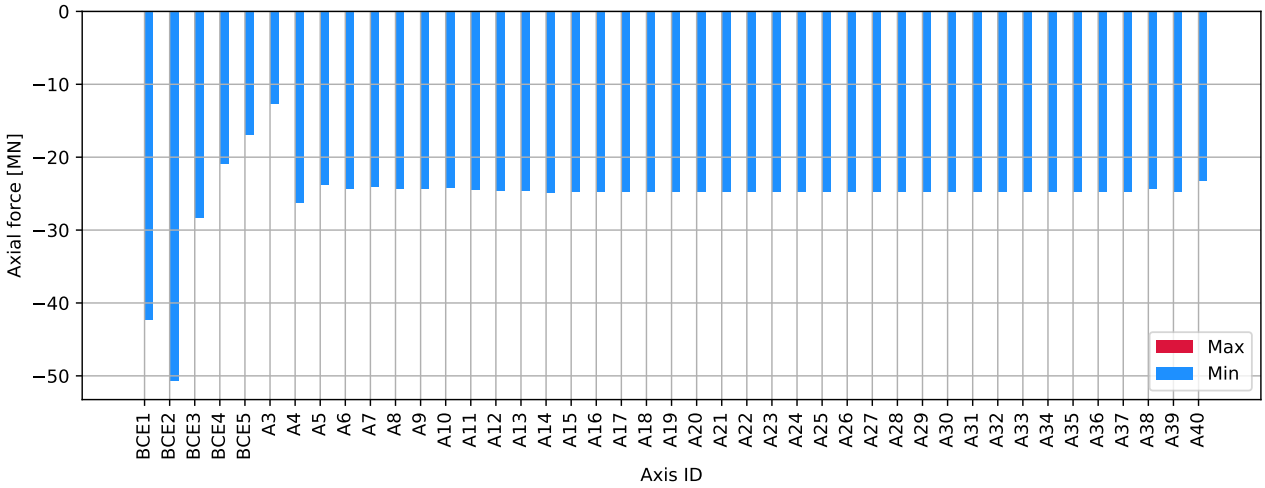

Figure 3.18: P A3 0deg - columns top : Axial force [MN]

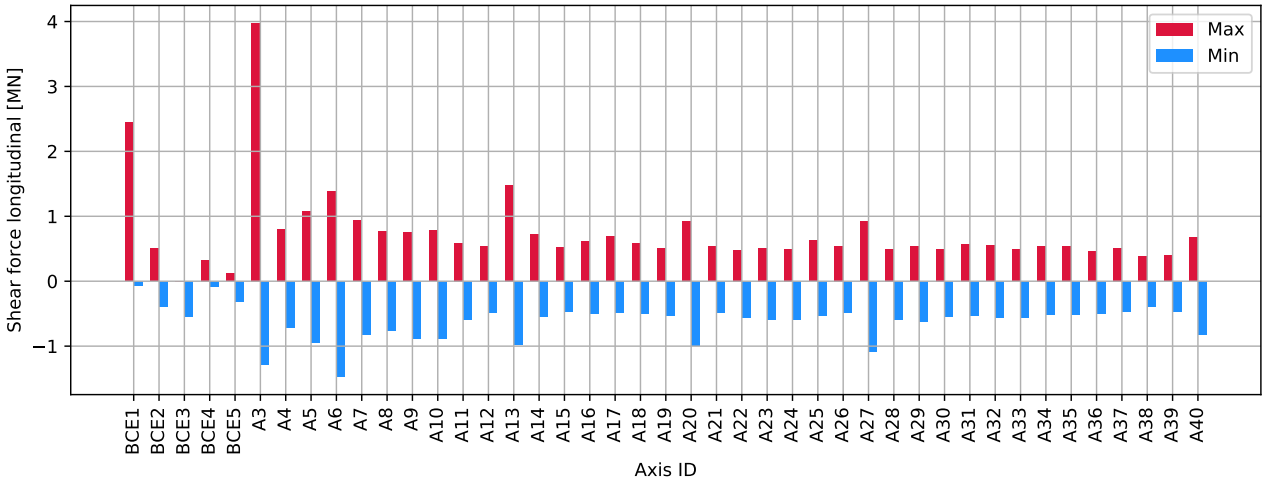

Figure 3.19: P A3 0deg - columns top : Shear force longitudinal [MN]

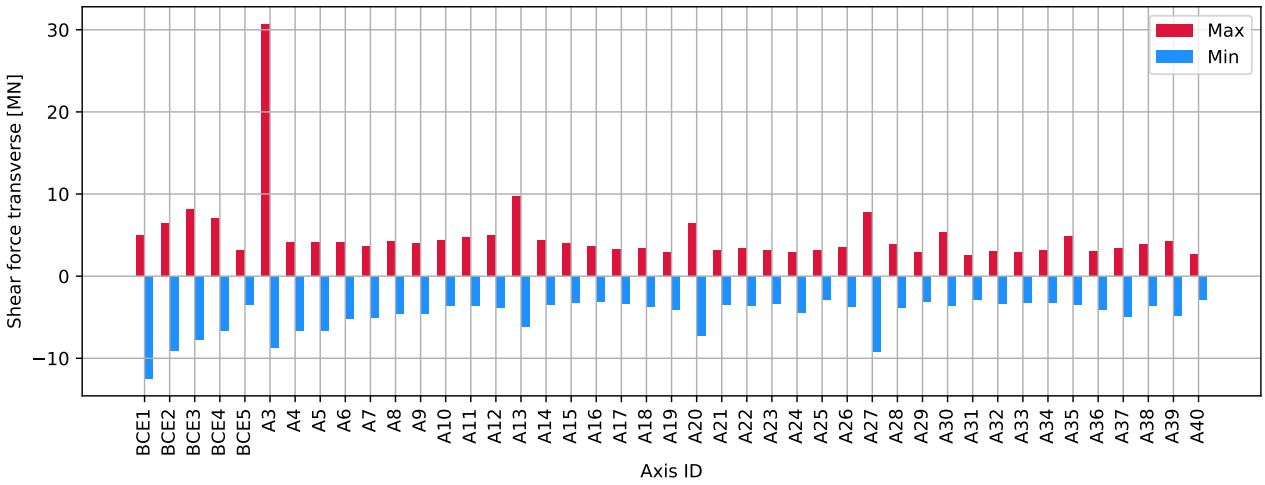

Figure 3.20: P A3 0deg - columns top : Shear force transverse [MN]

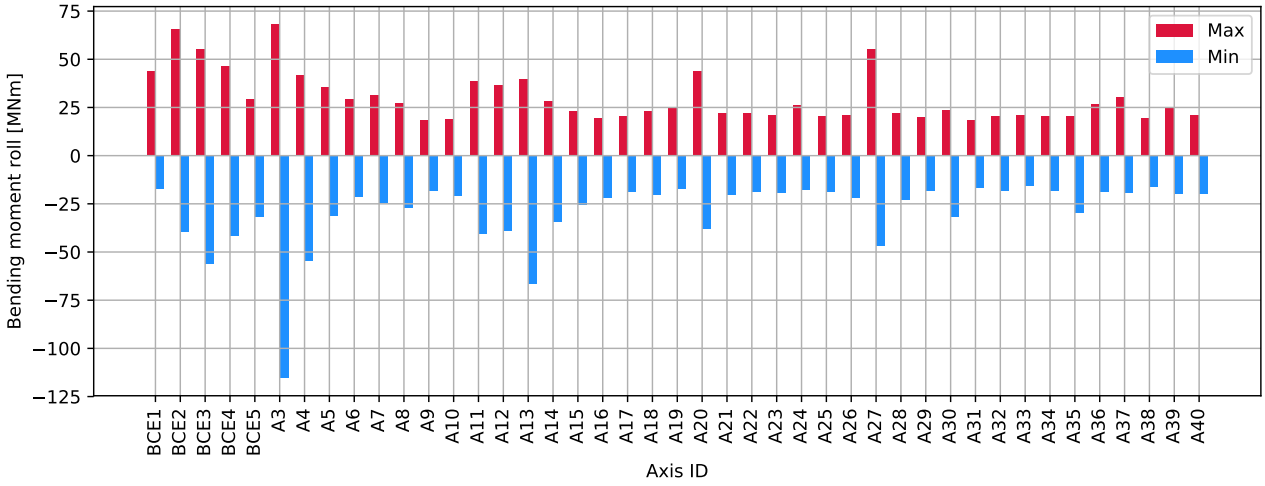

Figure 3.21: P A3 0deg - columns top : Bending moment roll [MNm]

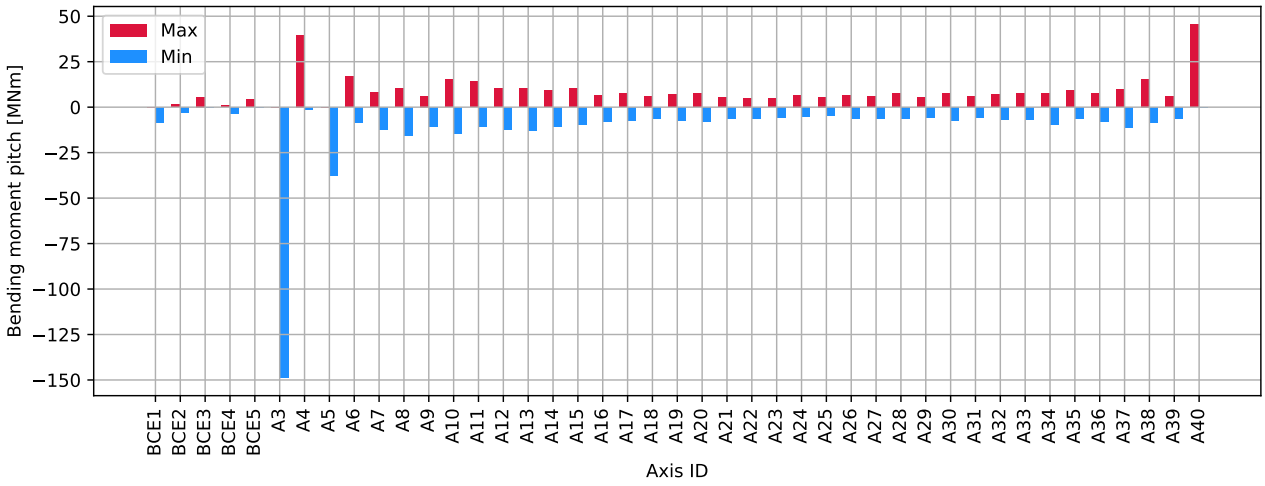

Figure 3.22: P A3 0deg - columns top : Bending moment pitch [MNm]

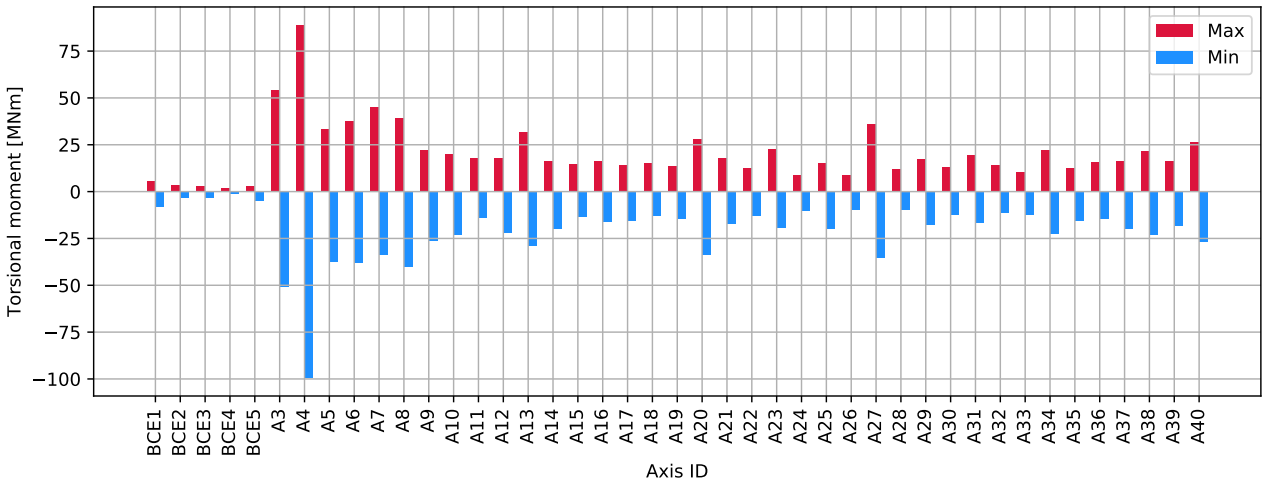

Figure 3.23: P A3 0deg - columns top : Torsional moment [MNm]

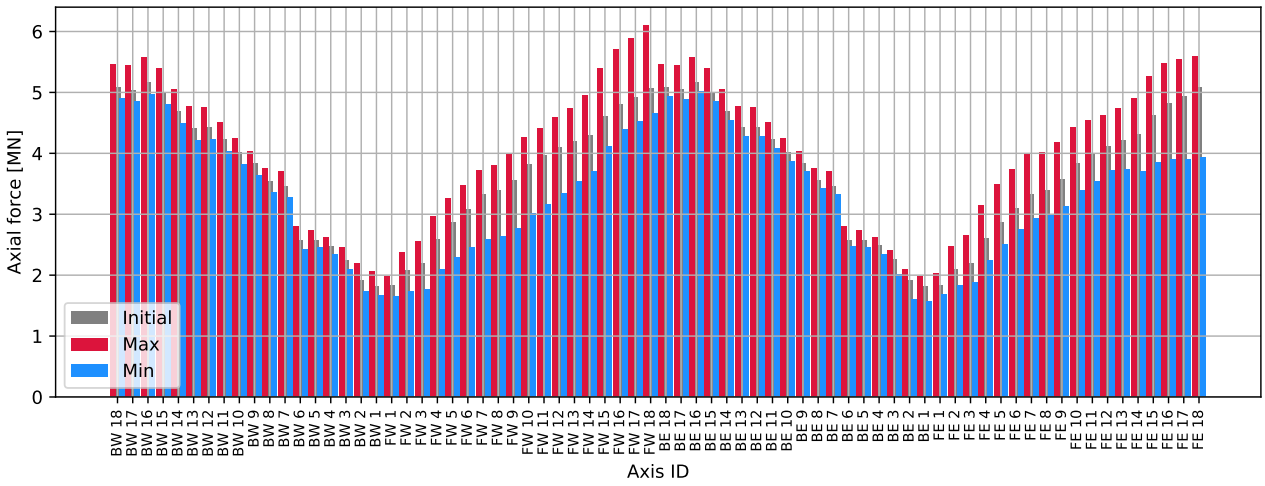

Figure 3.24: P A3 0deg - cables : Axial force [MN]

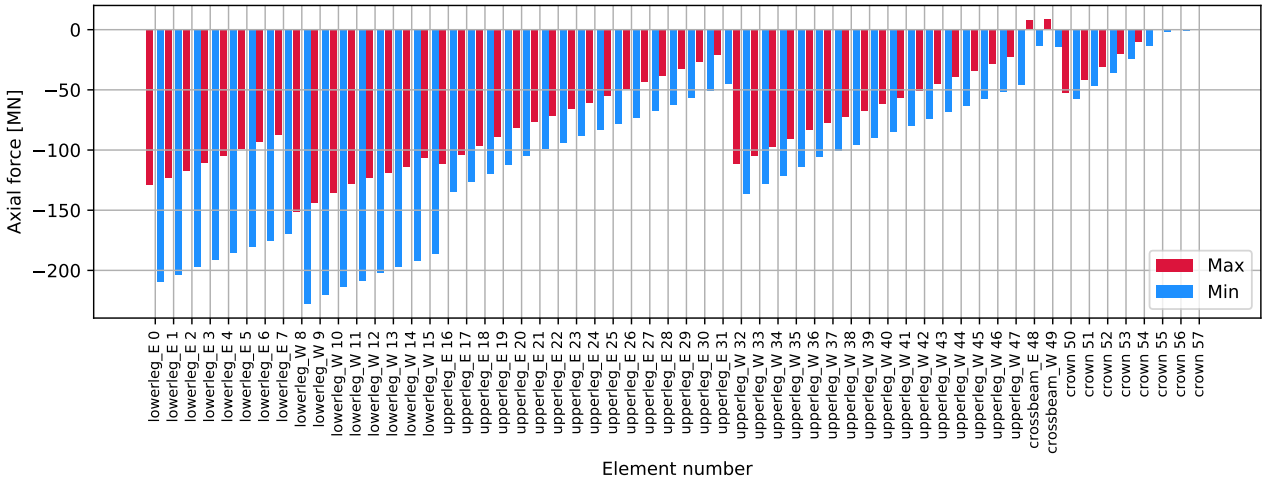

Figure 3.25: P A3 0deg - tower: Axial force [MN]

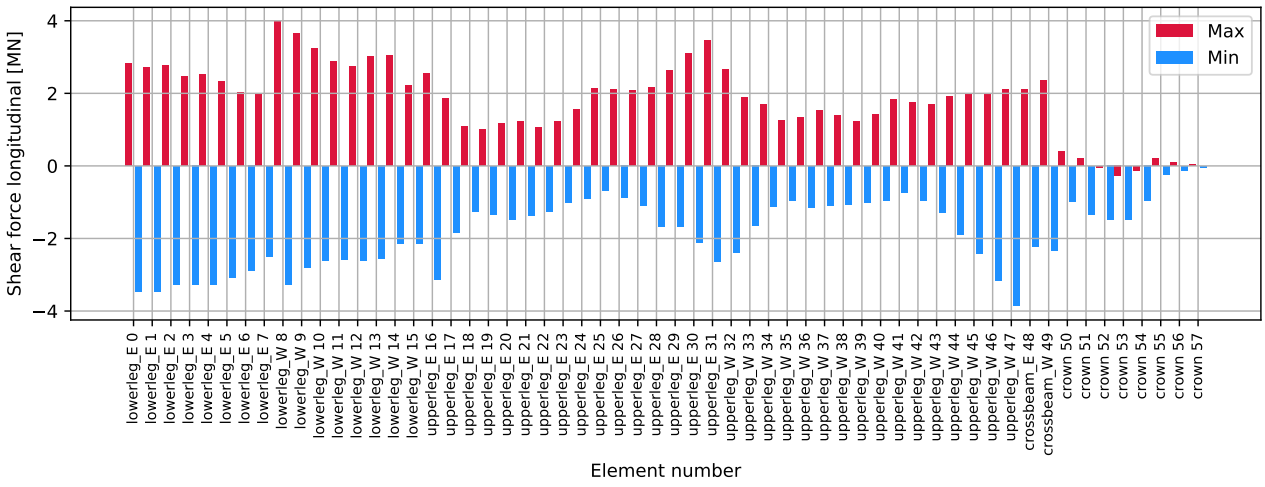

Figure 3.26: P A3 0deg - tower: Shear force longitudinal [MN]

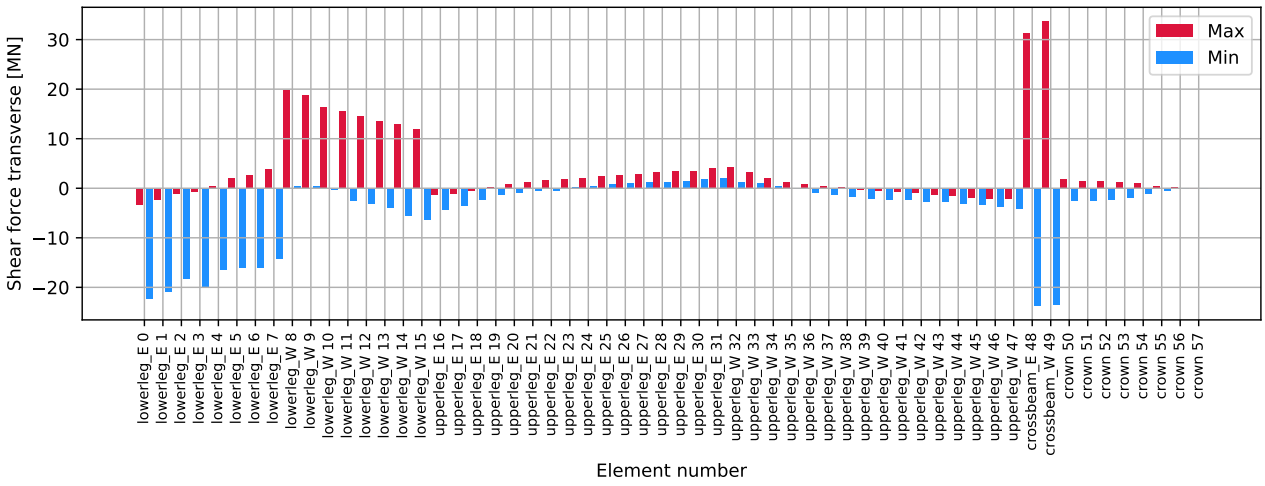

Figure 3.27: P A3 0deg - tower: Shear force transverse [MN]

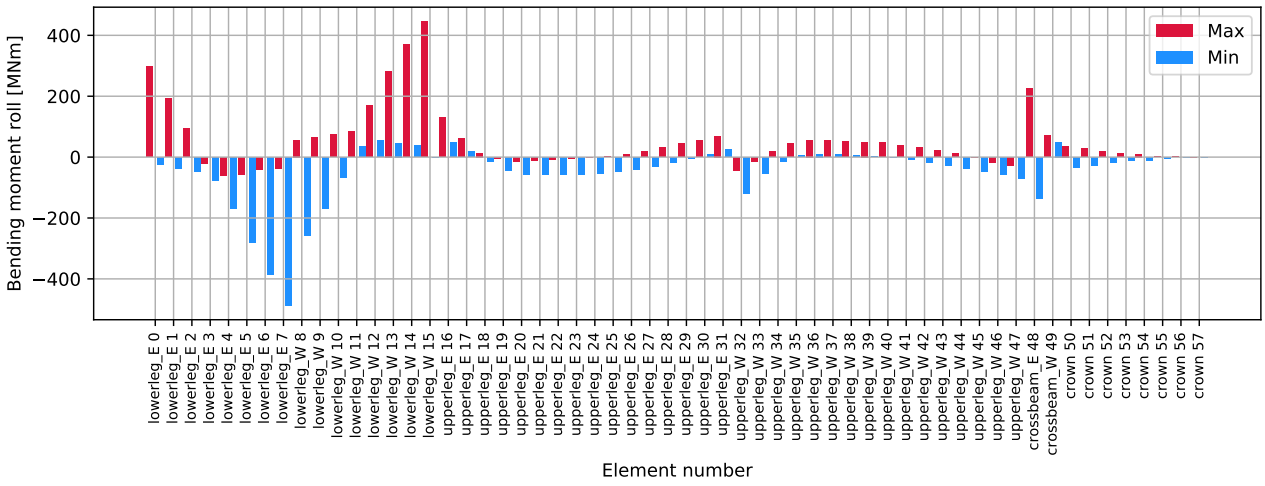

Figure 3.28: P A3 0deg - tower: Bending moment roll [MNm]

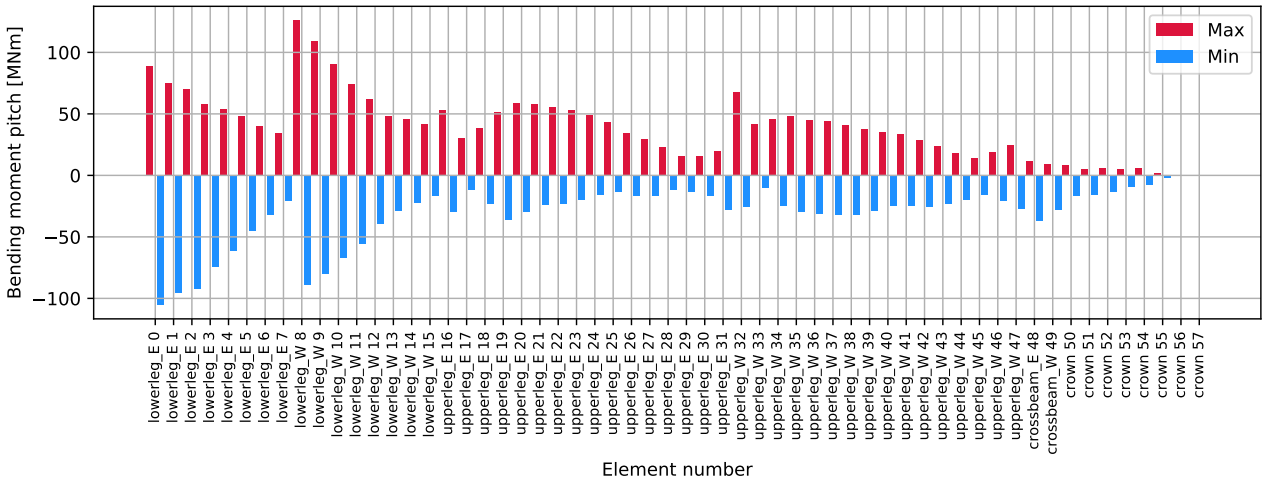

Figure 3.29: P A3 0deg - tower: Bending moment pitch [MNm]

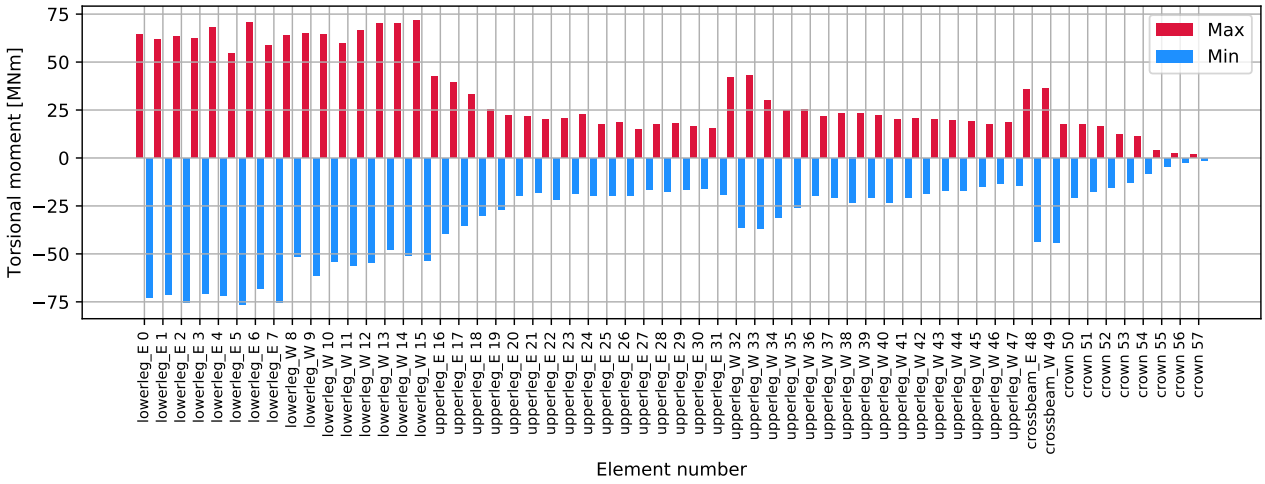

Figure 3.30: P A3 0deg - tower: Torsional moment [MNm]

3.1.3 Time series

Note : Time series are filtered using a Saviotzky-Golay filter for increased readability of the time history plots. Hence, maximum values that occur due to a rapid vibration are not shown in the plots. For maximum values, refer to the tabulated data.
All elements are numbered from South to North, bottom to top

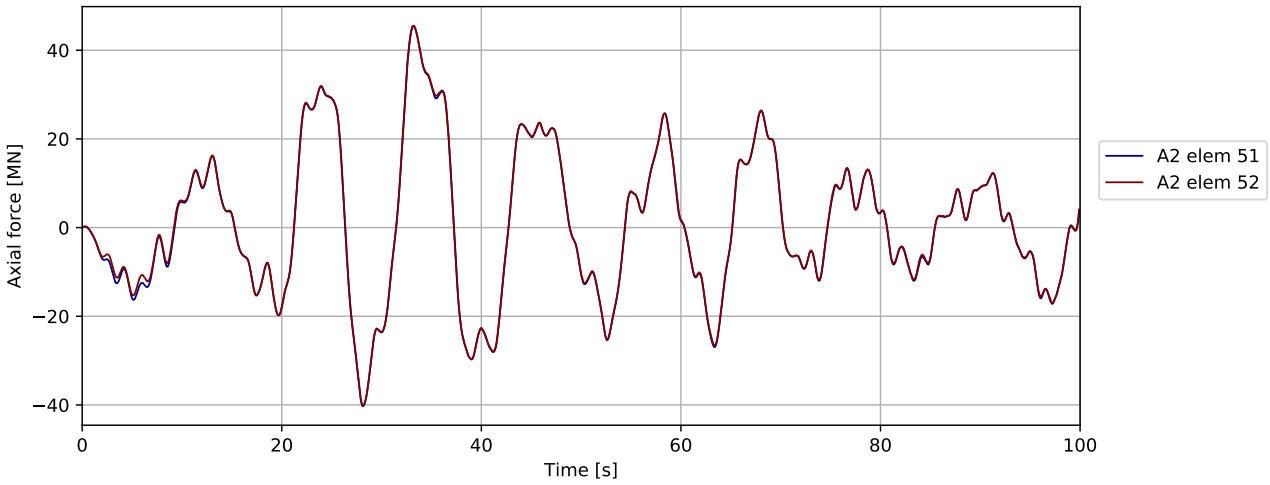

Figure 3.31: P A3 0deg - bridgegirder @ pylon: Axial force [MN]

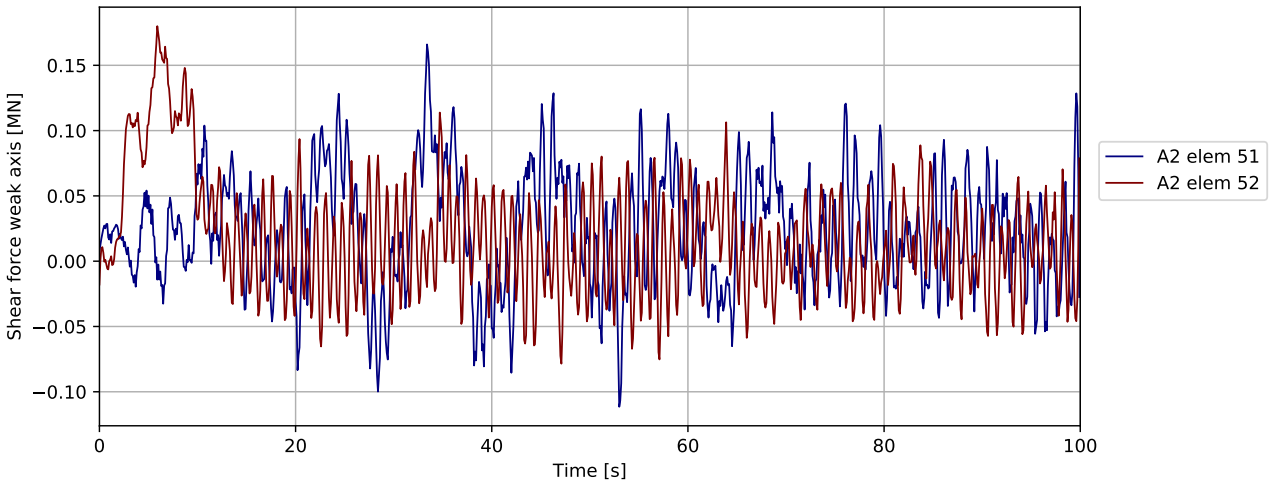

Figure 3.32: P A3 0deg - bridgegirder @ pylon: Shear force weak axis [MN]

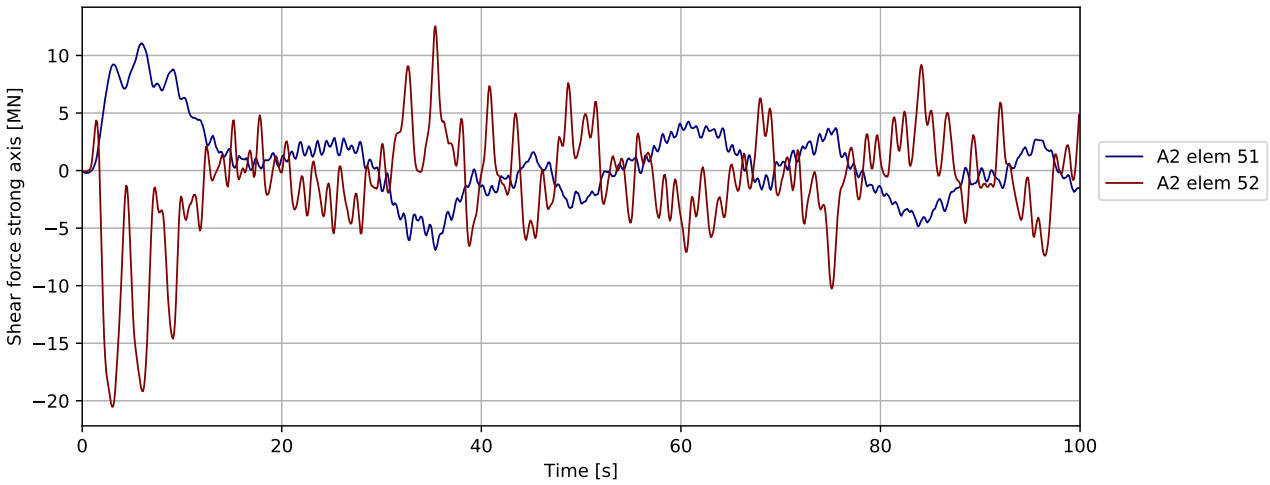

Figure 3.33: P A3 0deg - bridgegirder @ pylon: Shear force strong axis [MN]

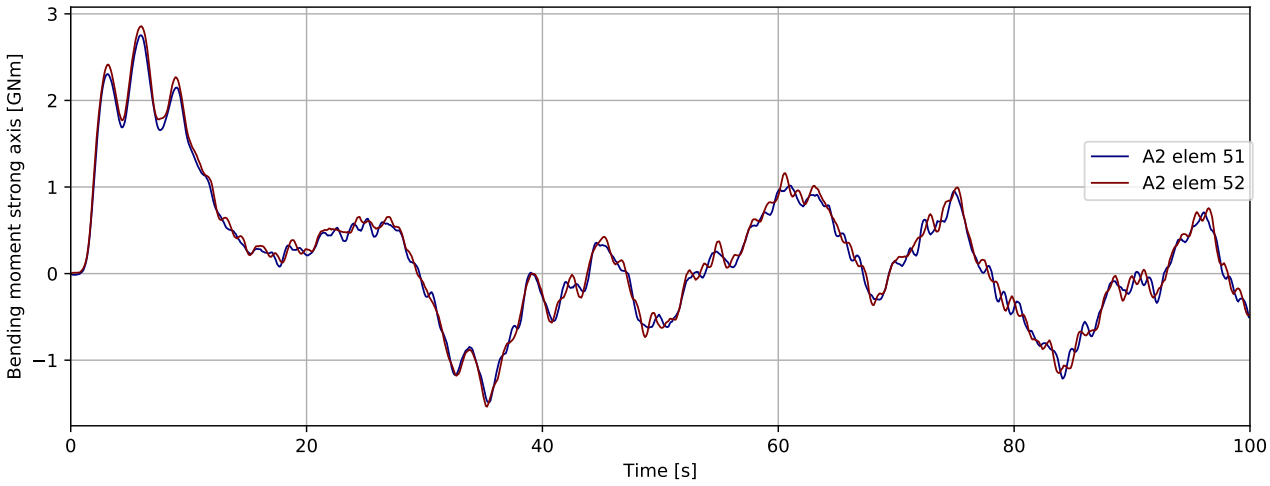

Figure 3.34: P A3 0deg - bridgegirder @ pylon: Bending moment strong axis [GNm]

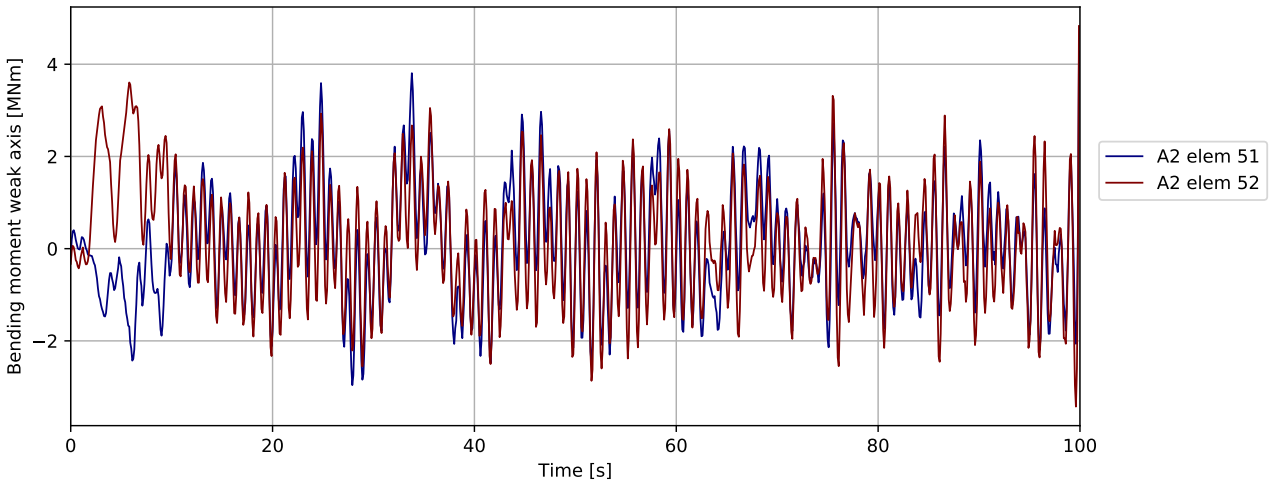

Figure 3.35: P A3 0deg - bridgegirder @ pylon: Bending moment weak axis [MNm]

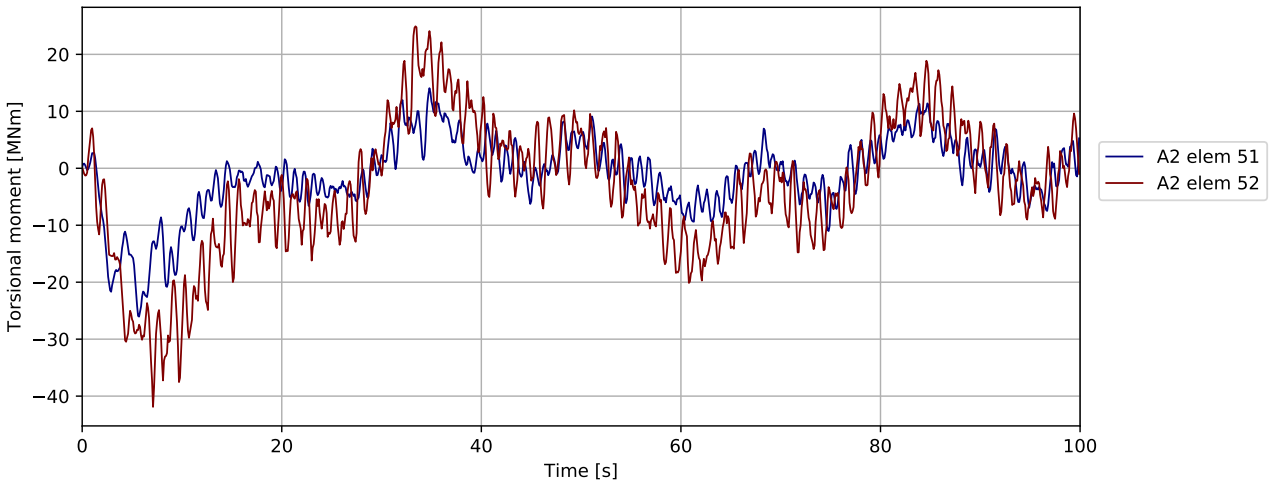

Figure 3.36: P A3 0deg - bridgegirder @ pylon: Torsional moment [MNm]

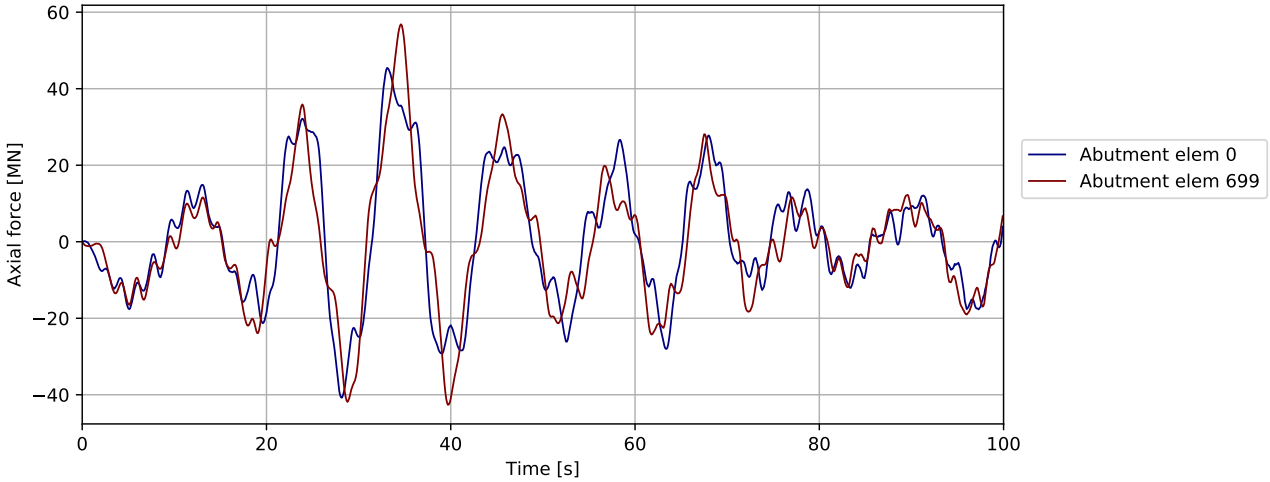

Figure 3.37: P A3 0deg - bridgegirder @abutments: Axial force [MN]

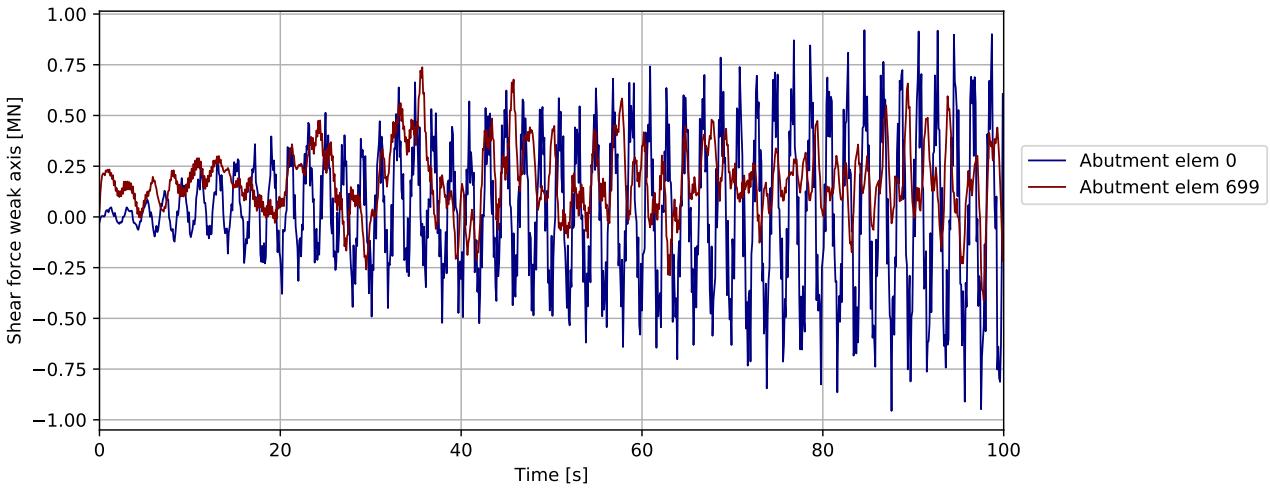

Figure 3.38: P A3 0deg - bridgegirder @abutments: Shear force weak axis [MN]

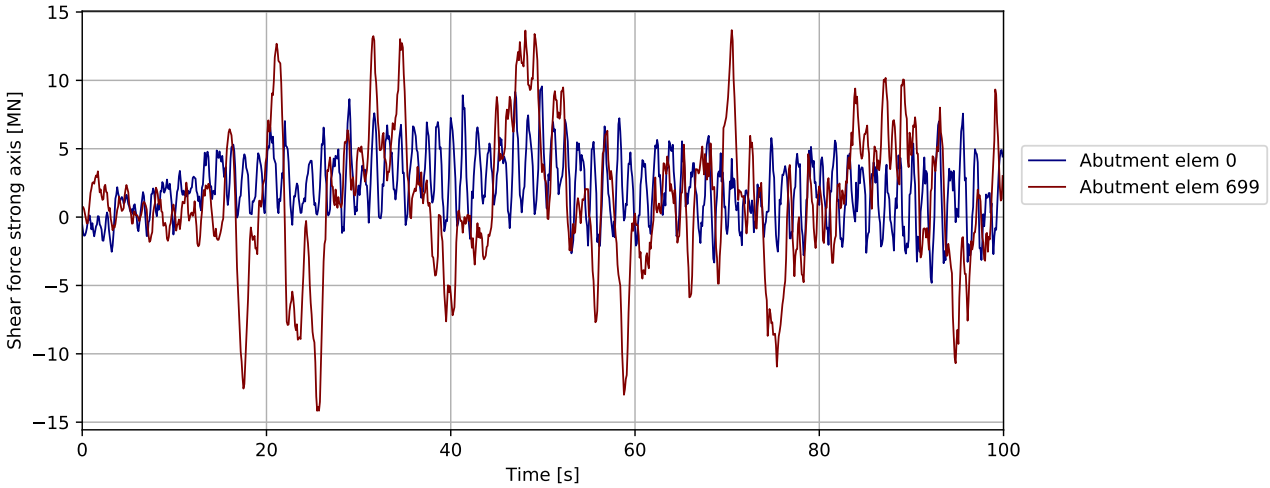

Figure 3.39: P A3 0deg - bridgegirder @abutments: Shear force strong axis [MN]

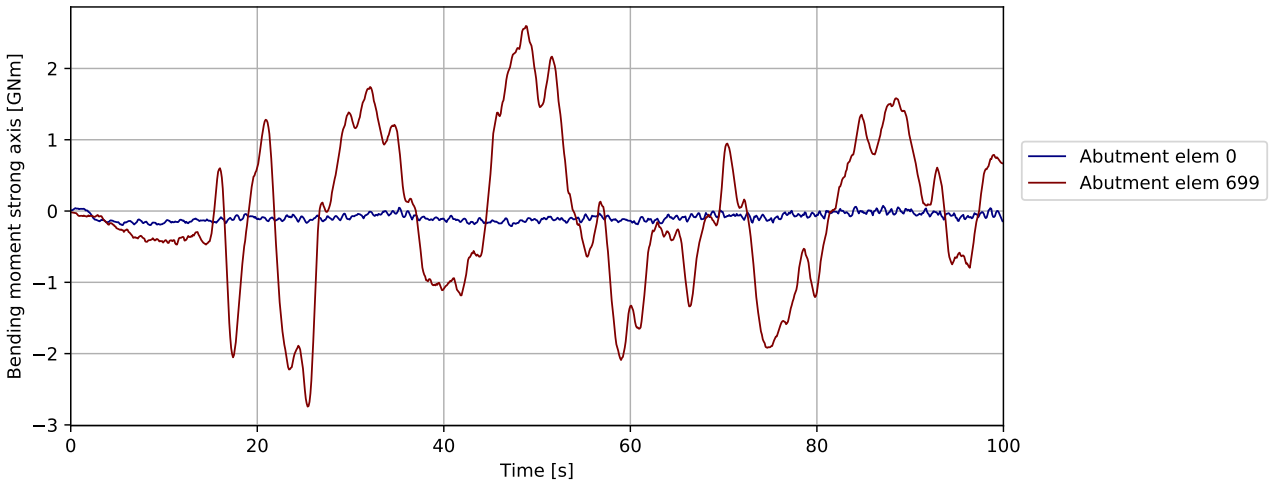

Figure 3.40: P A3 0deg - bridgegirder @abutments: Bending moment strong axis [GNm]

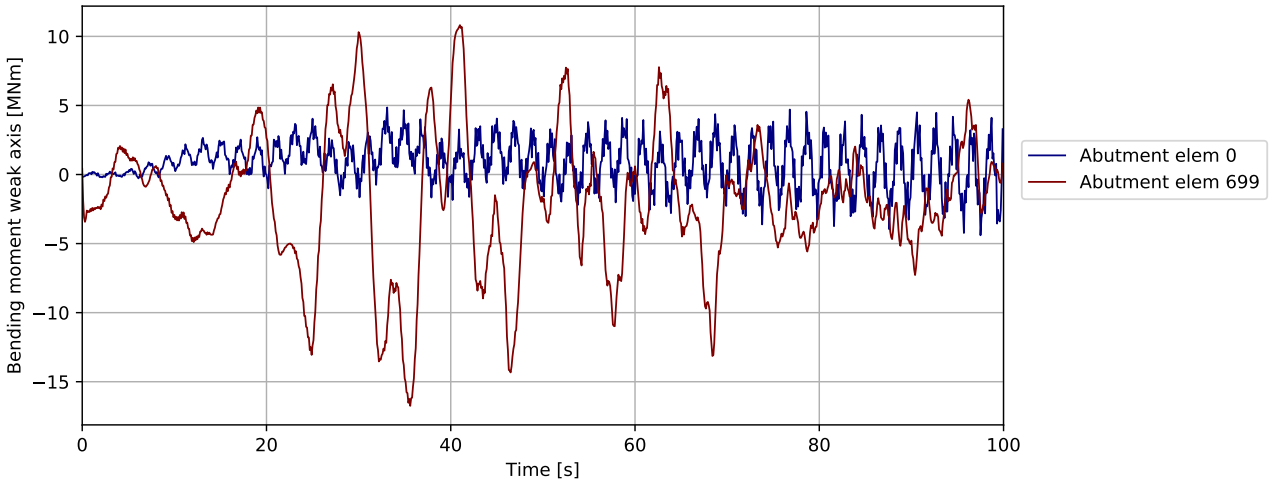

Figure 3.41: P A3 0deg - bridgegirder @abutments: Bending moment weak axis [MNm]

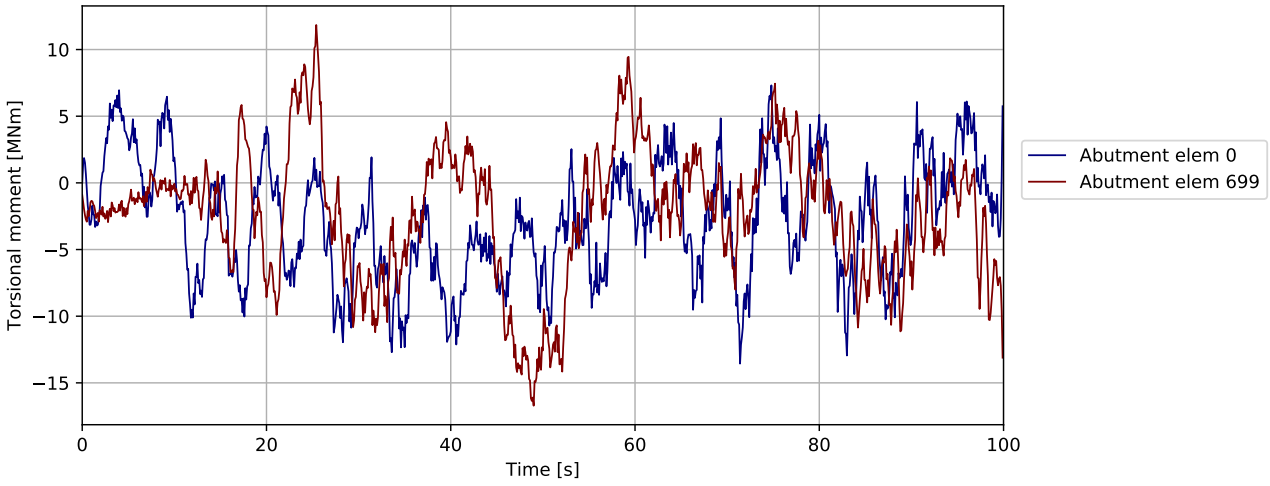

Figure 3.42: P A3 0deg - bridgegirder @abutments: Torsional moment [MNm]

Note : Compressive spring force is negative

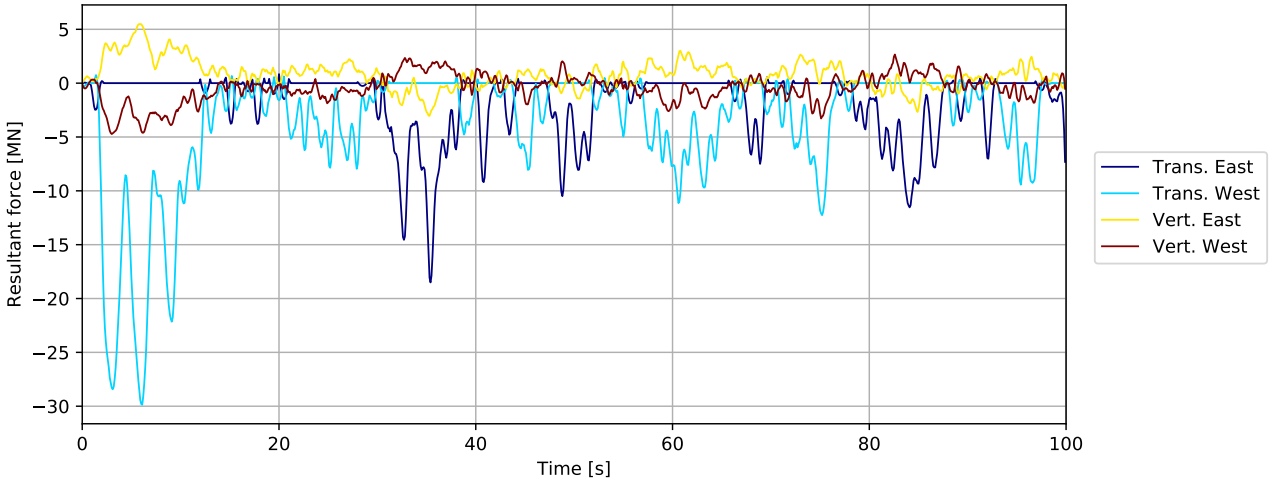

Figure 3.43: P A3 0deg - bridgegirder supports in tower: Resultant force [MN]

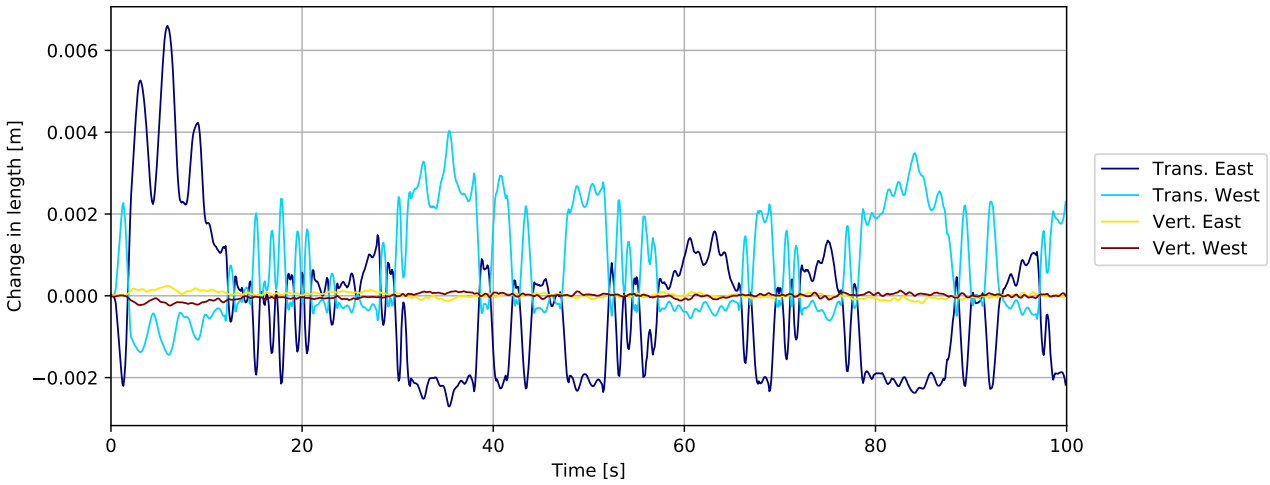

Figure 3.44: P A3 0deg - bridgegirder supports in tower: Change in length [m]

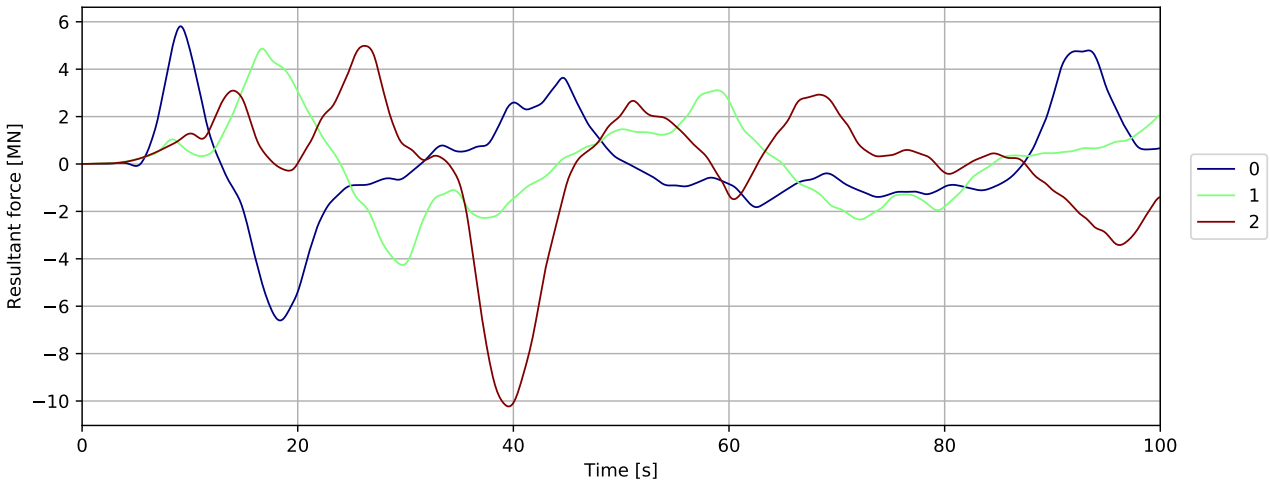

Figure 3.45: Mooring force

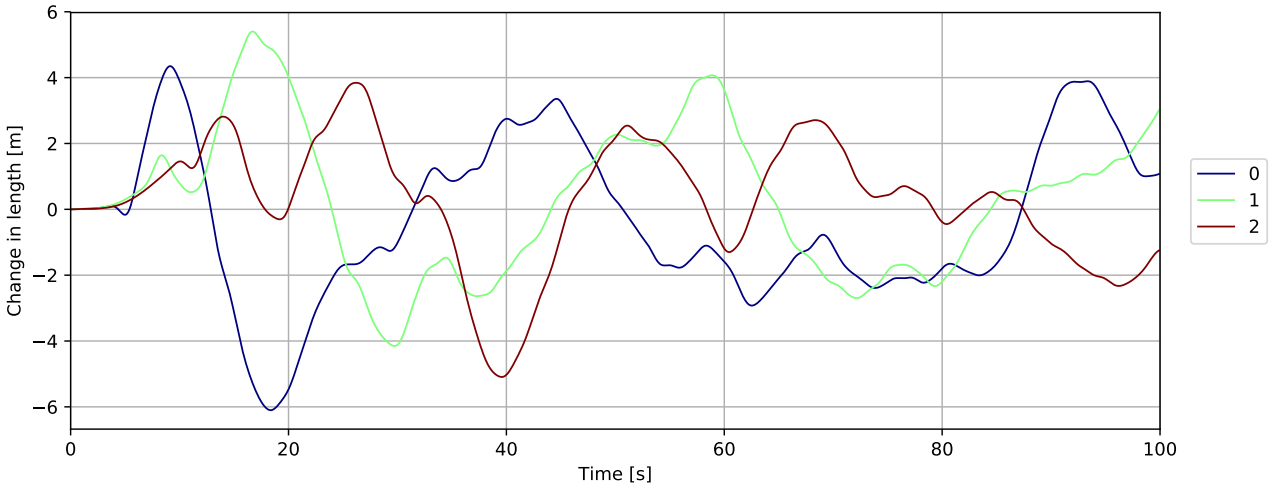

Figure 3.46: Mooring displacement

3.2 PontoonA4 0deg

3.2.1 Overall response

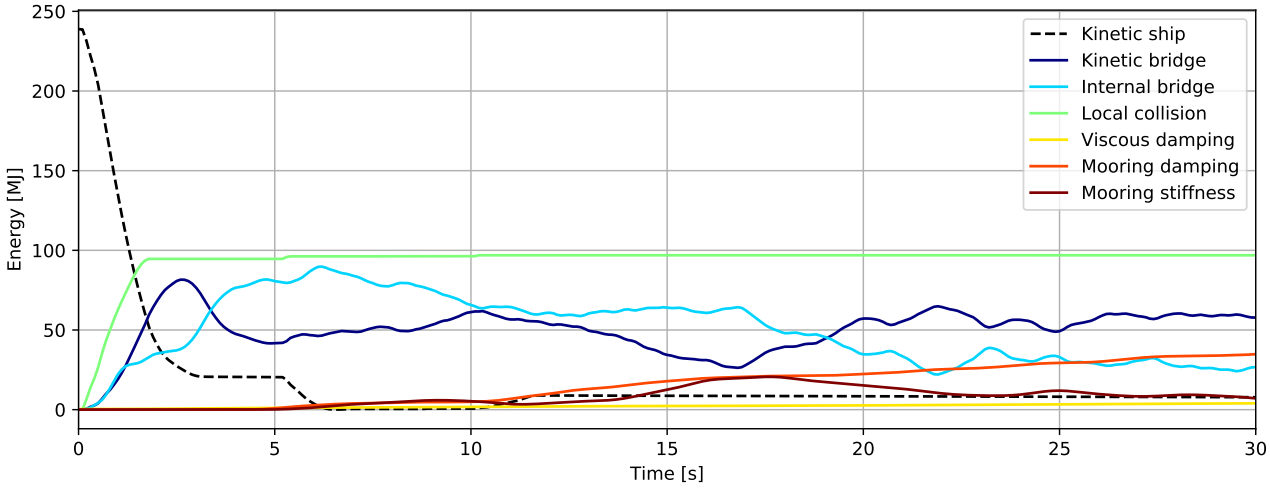

Figure 3.47: Energy [MJ] - initial phase

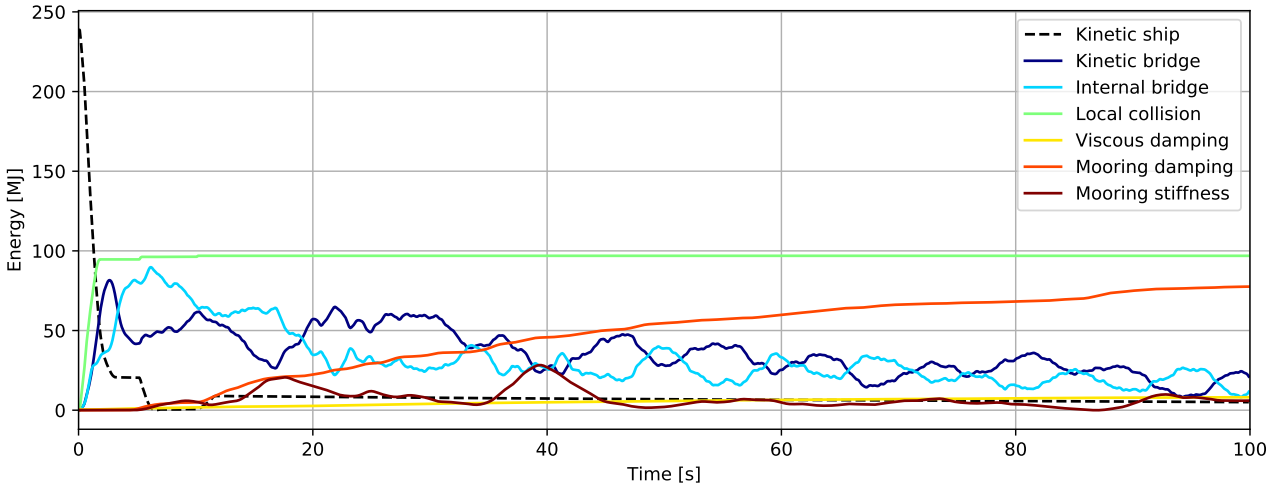

Figure 3.48: Energy [MJ]

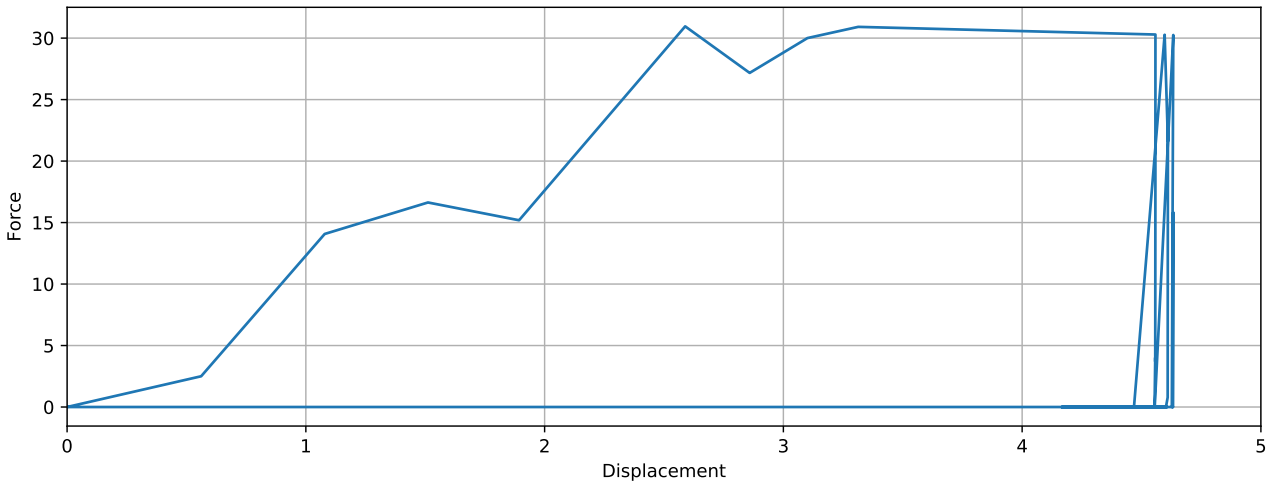

Figure 3.49: Simulated local collision force-displacement

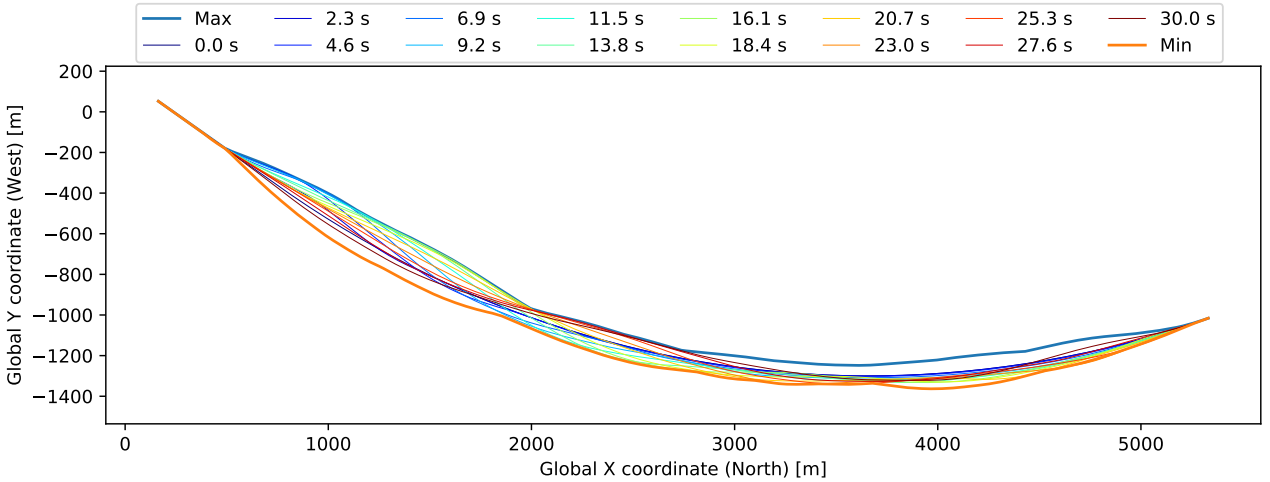

Figure 3.50: Bridgegirder deflection (10x displacment scaling)

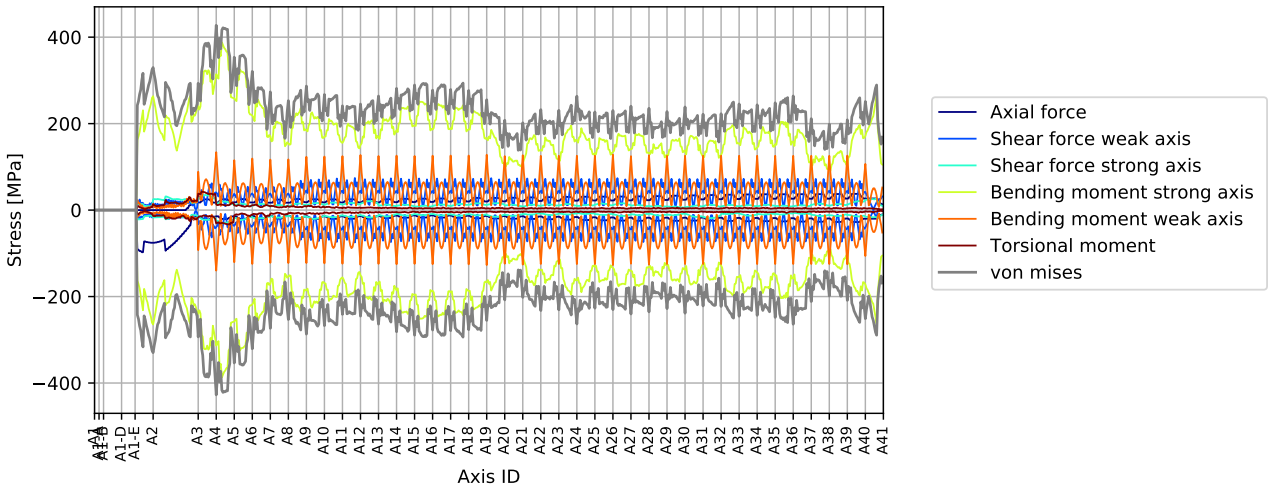

Figure 3.51: Stress envelope from all force components

3.2.2 Envelope plots

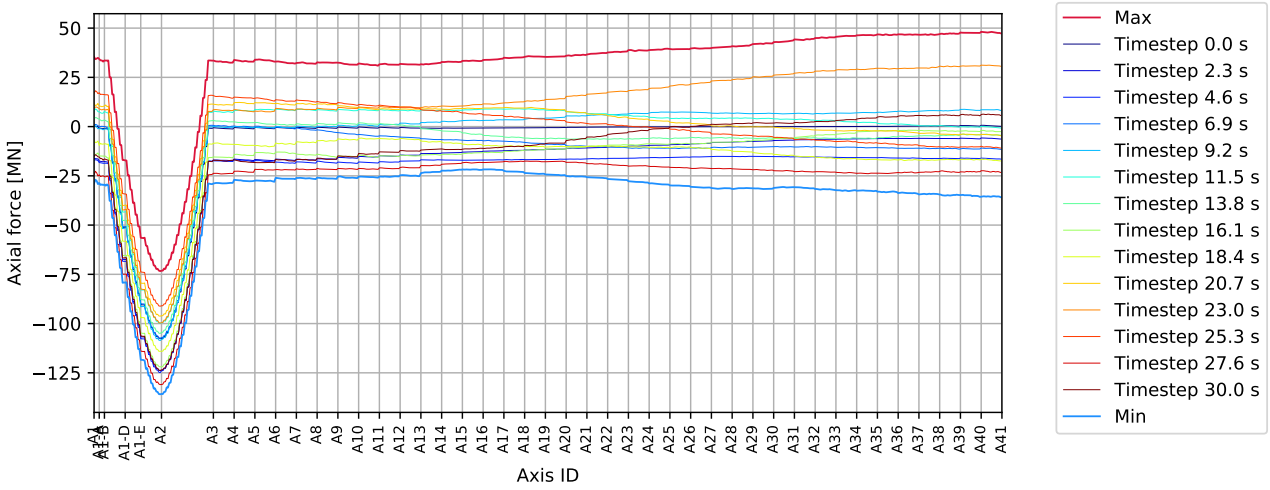

Figure 3.52: P A4 0deg - bridgegirder : Axial force [MN]

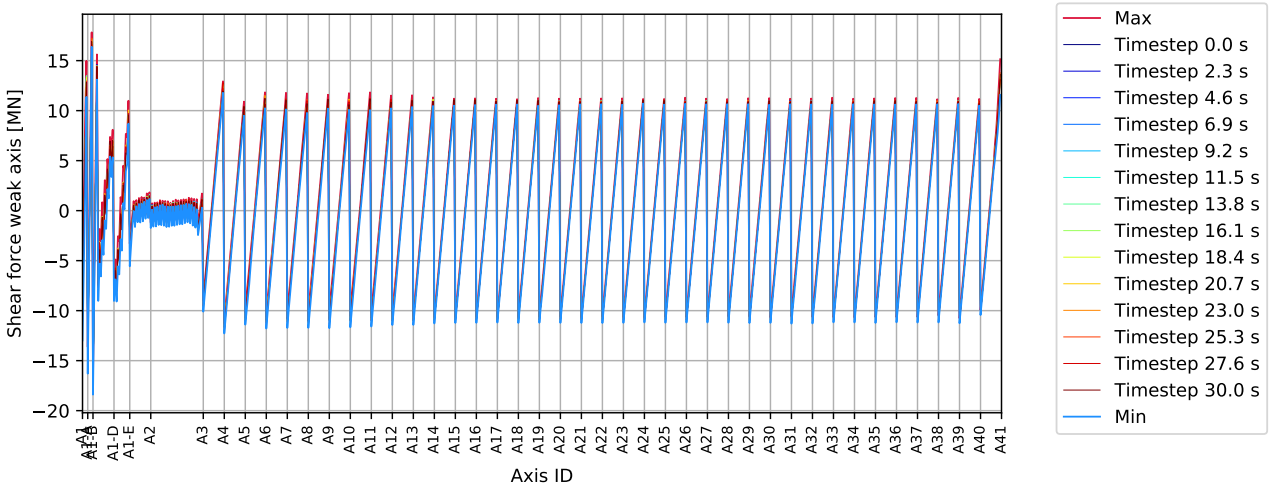

Figure 3.53: P A4 0deg - bridgegirder : Shear force weak axis [MN]

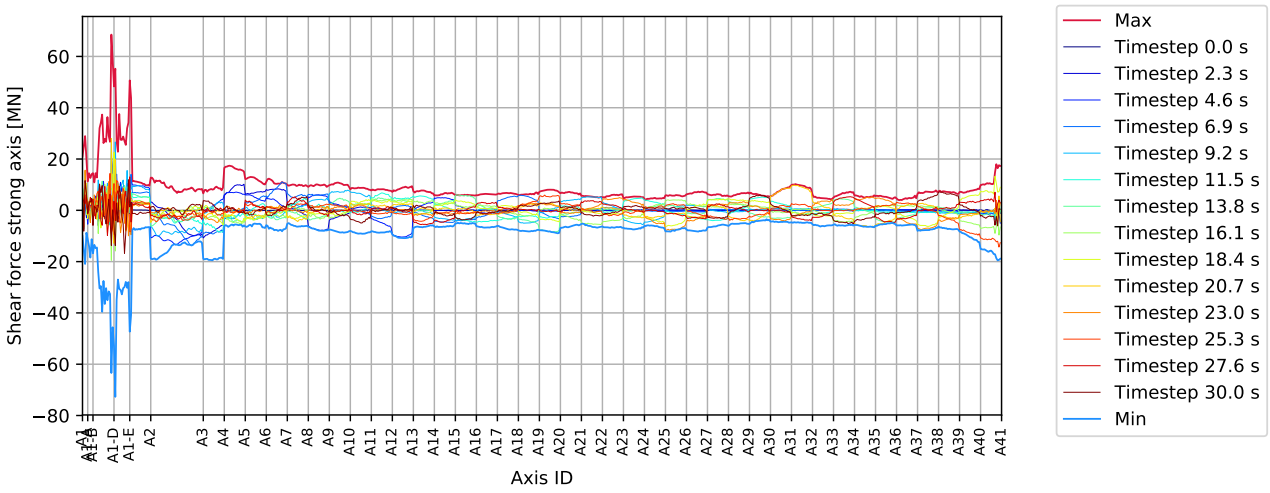

Figure 3.54: P A4 0deg - bridgegirder : Shear force strong axis [MN]

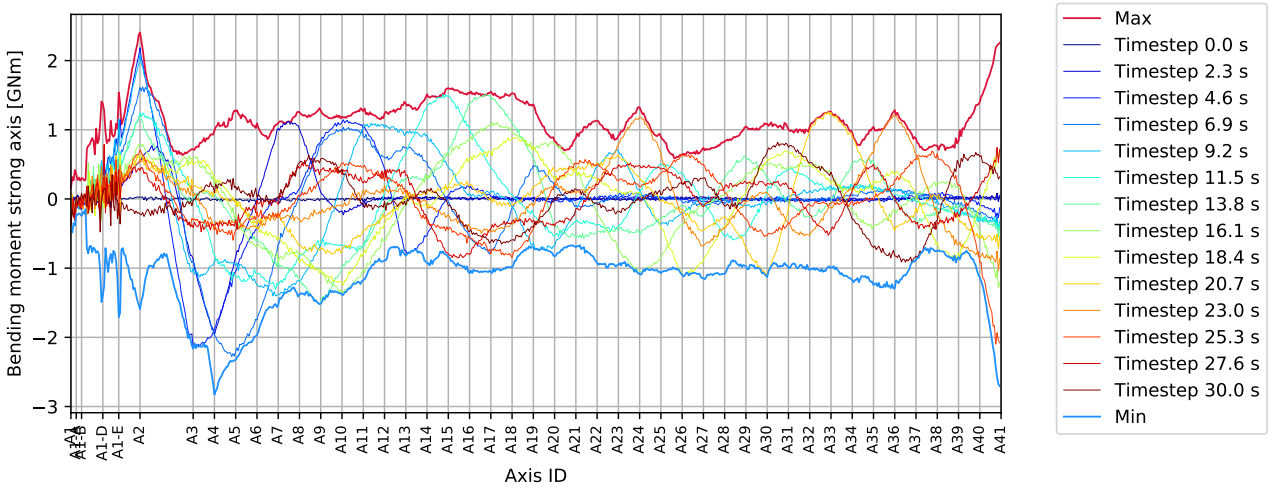

Figure 3.55: P A4 0deg - bridgegirder : Bending moment strong axis [GNm]

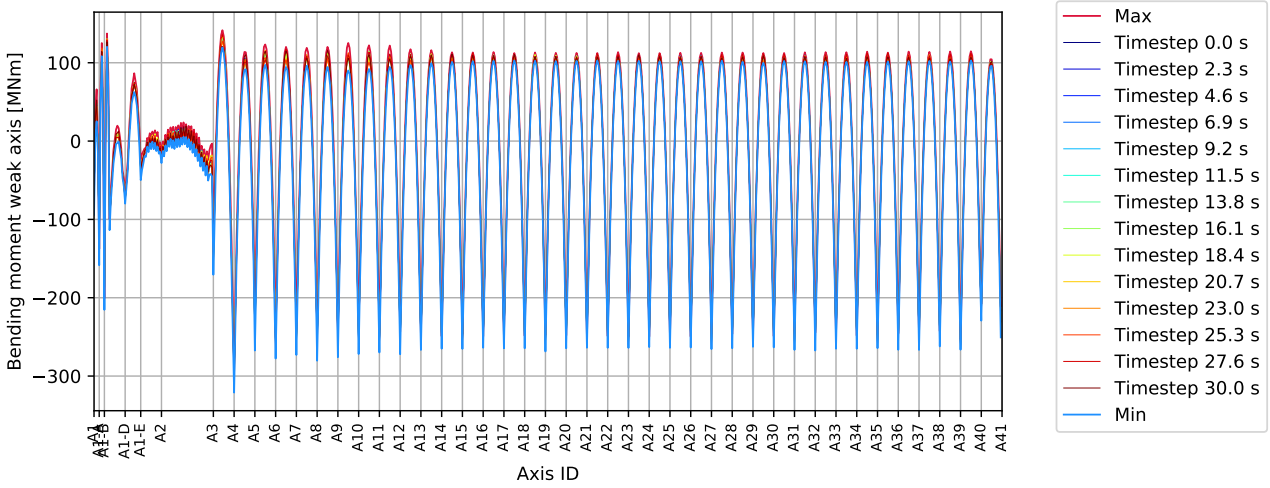

Figure 3.56: P A4 0deg - bridgegirder : Bending moment weak axis [MNm]

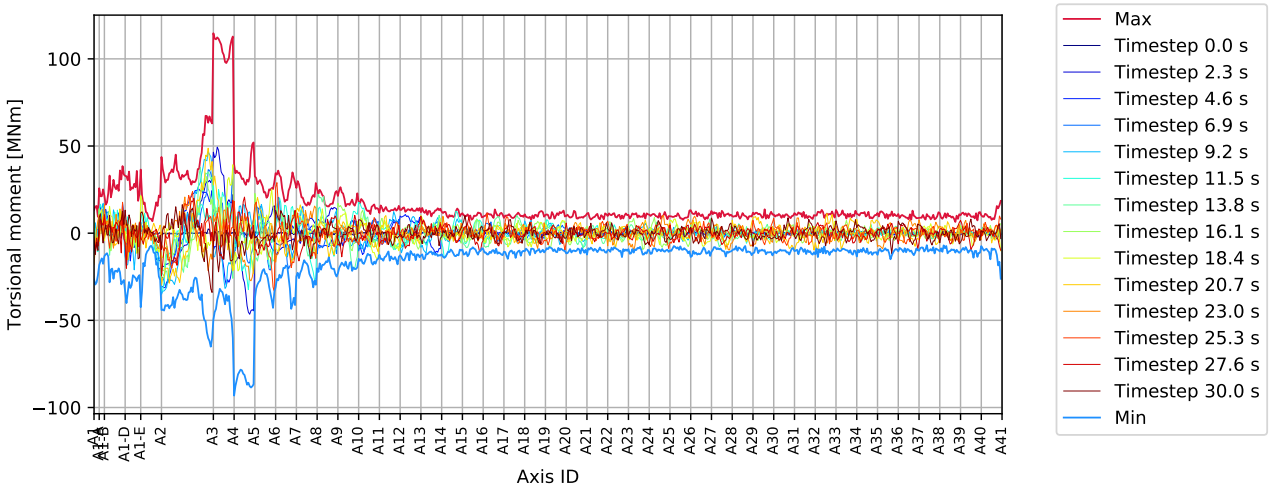

Figure 3.57: P A4 0deg - bridgegirder : Torsional moment [MNm]

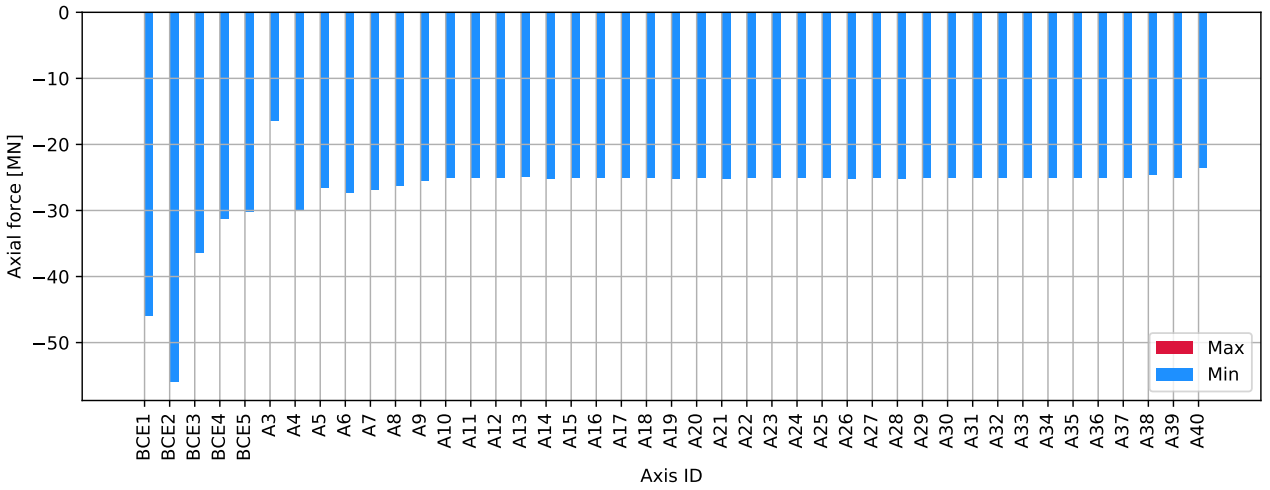

Figure 3.58: P A4 0deg - columns bottom : Axial force [MN]

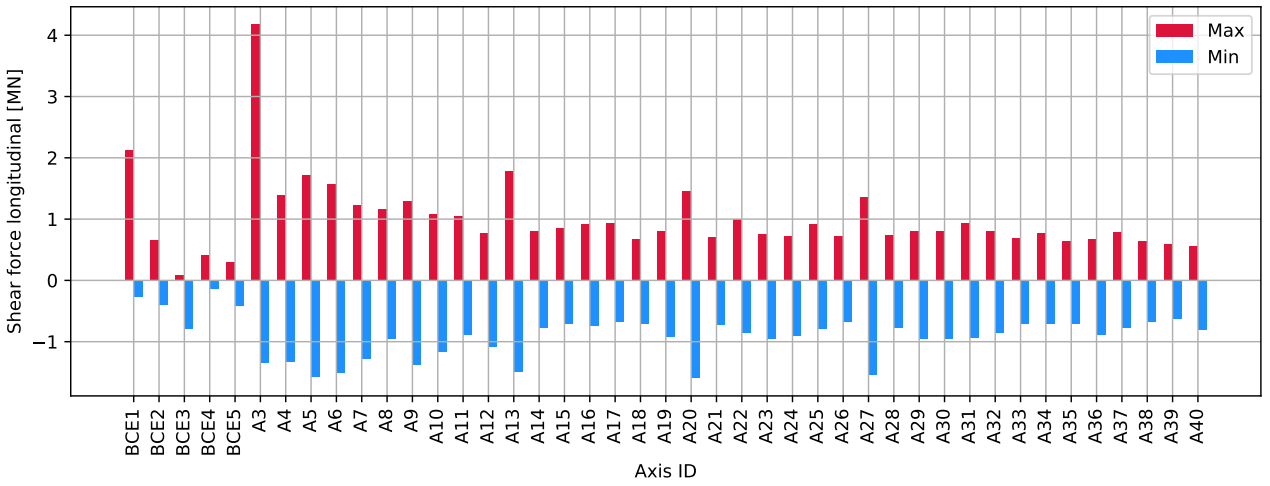

Figure 3.59: P A4 0deg - columns bottom : Shear force longitudinal [MN]

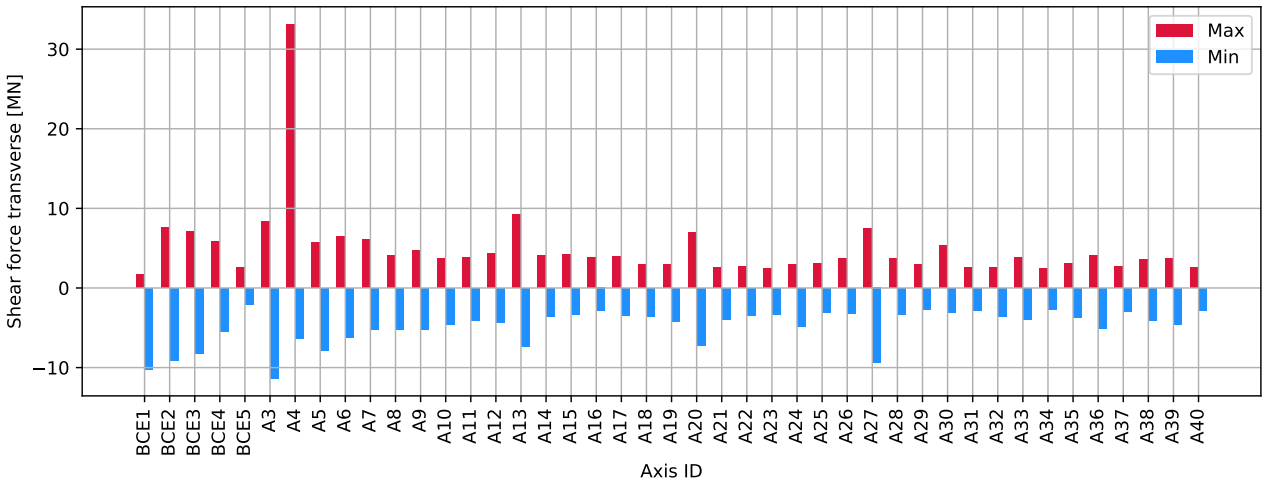

Figure 3.60: P A4 0deg - columns bottom : Shear force transverse [MN]

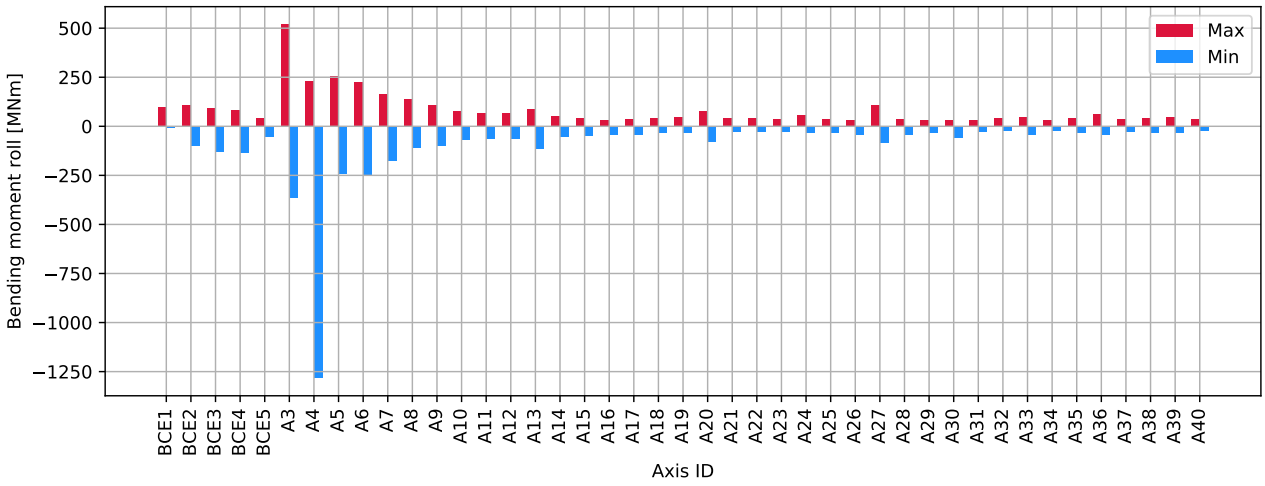

Figure 3.61: P A4 0deg - columns bottom : Bending moment roll [MNm]

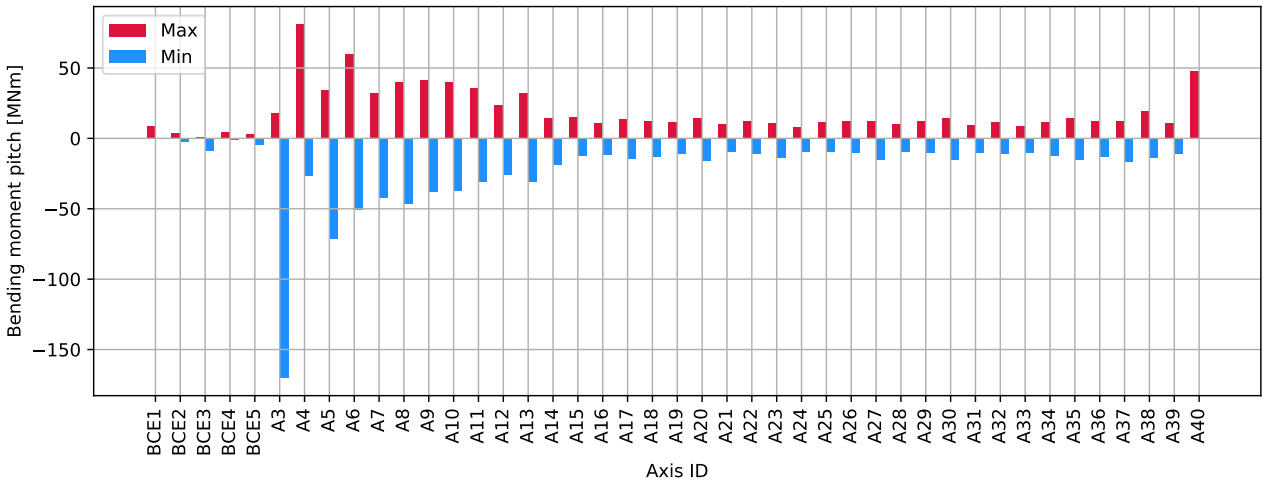

Figure 3.62: P A4 0deg - columns bottom : Bending moment pitch [MNm]

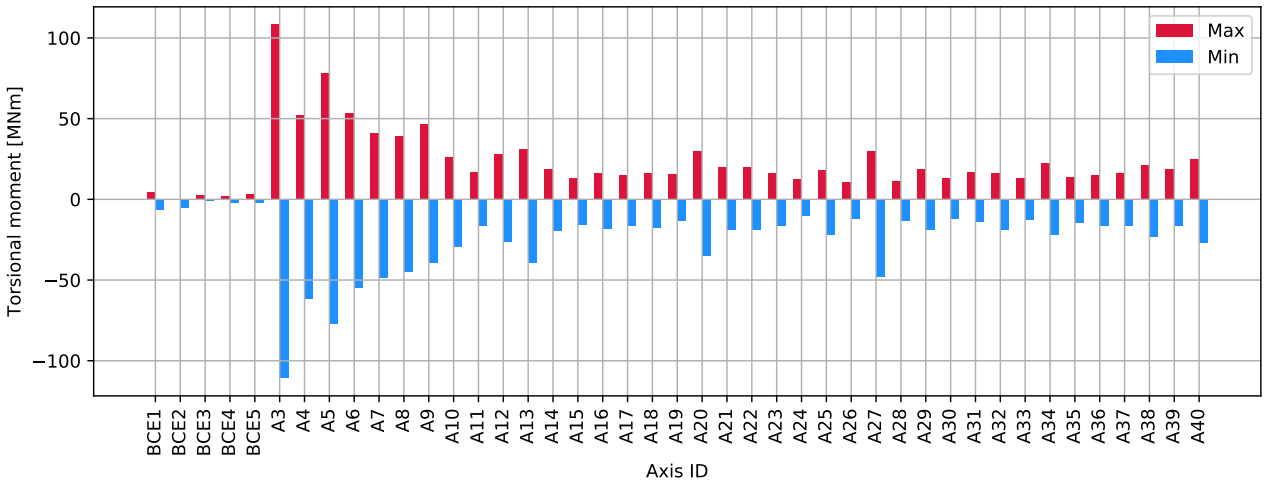

Figure 3.63: P A4 0deg - columns bottom : Torsional moment [MNm]

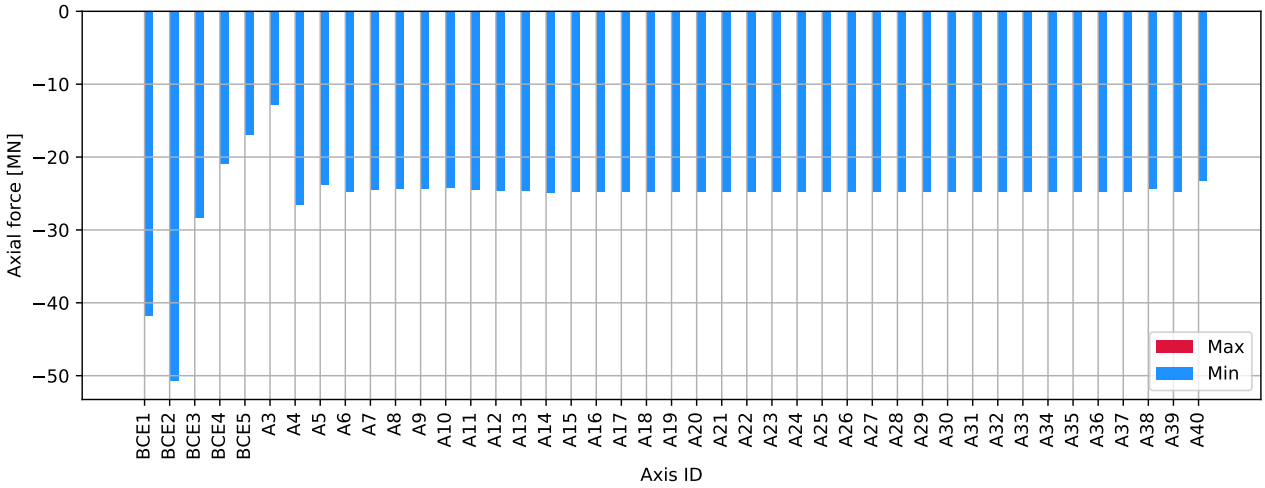

Figure 3.64: P A4 0deg - columns top : Axial force [MN]

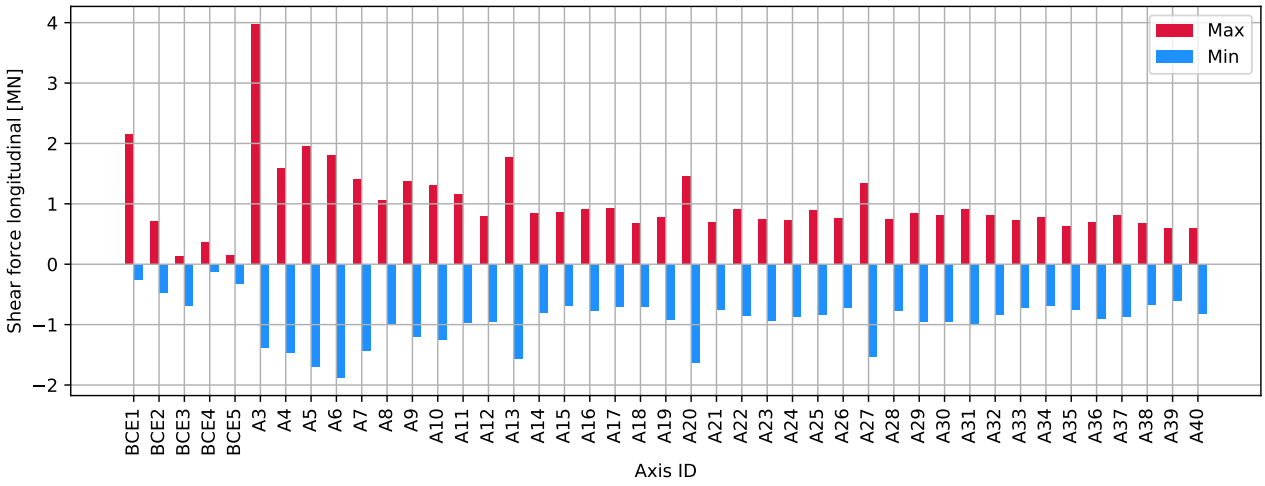

Figure 3.65: P A4 0deg - columns top : Shear force longitudinal [MN]

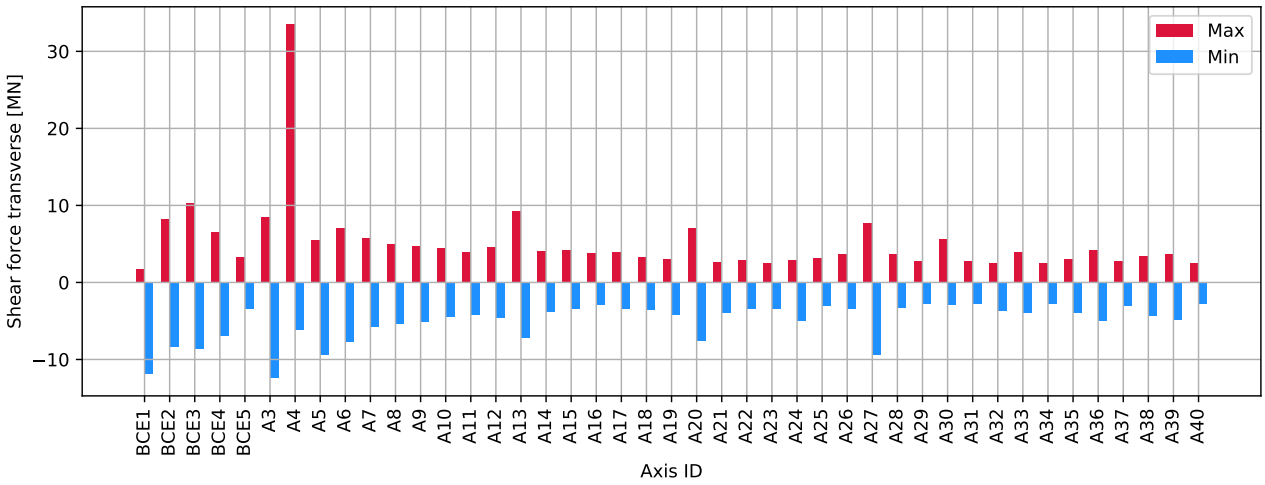

Figure 3.66: P A4 0deg - columns top : Shear force transverse [MN]

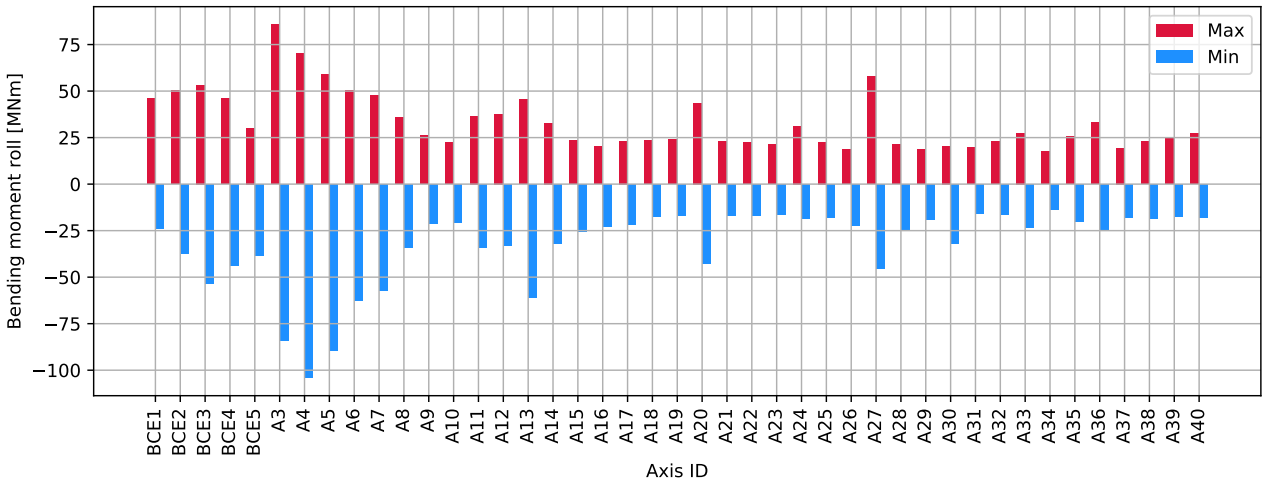

Figure 3.67: P A4 0deg - columns top : Bending moment roll [MNm]

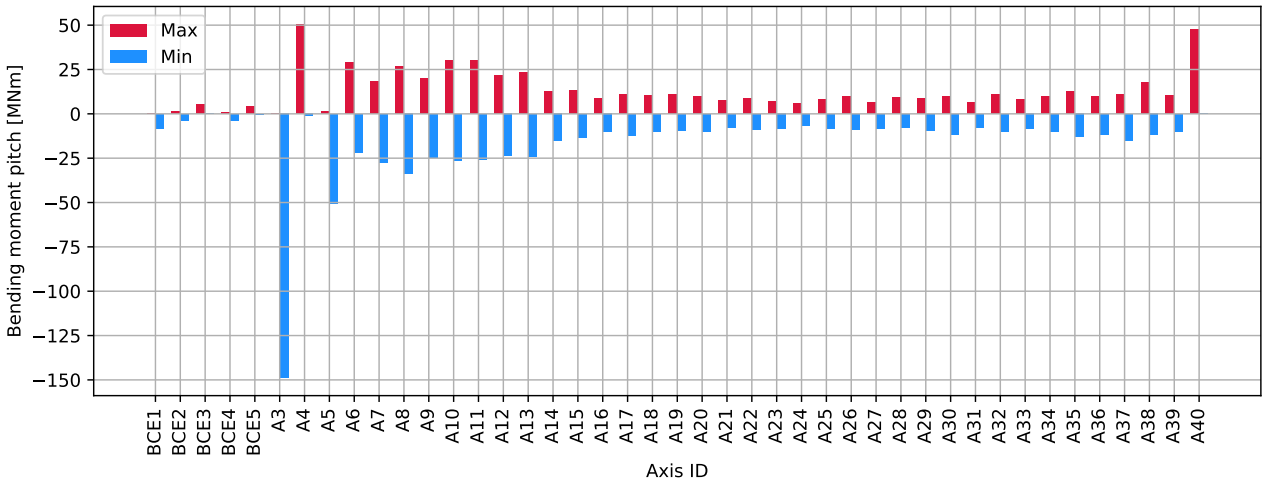

Figure 3.68: P A4 0deg - columns top : Bending moment pitch [MNm]

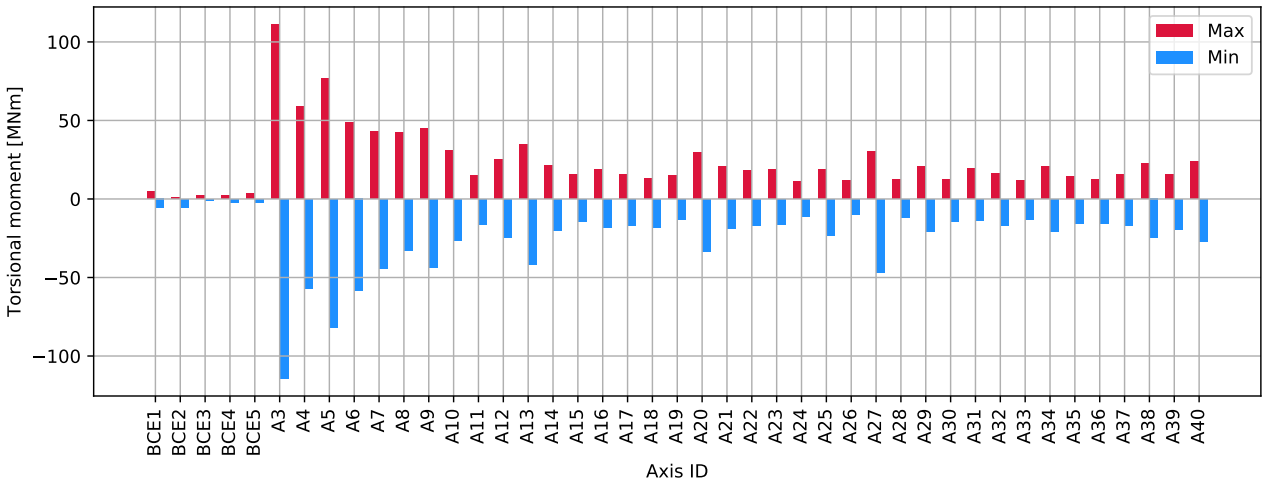

Figure 3.69: P A4 0deg - columns top : Torsional moment [MNm]

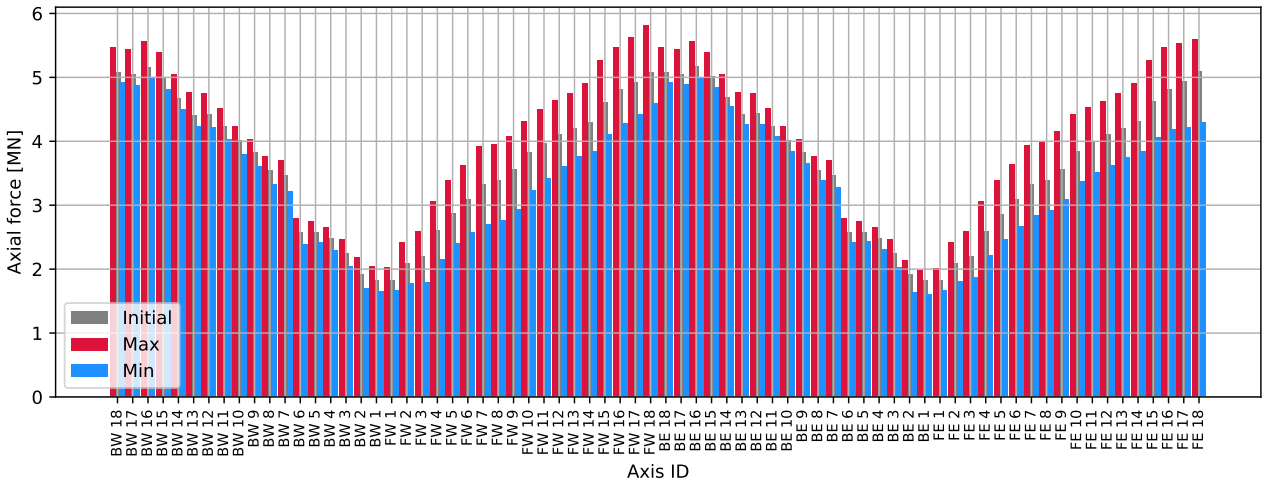

Figure 3.70: P A4 0deg - cables : Axial force [MN]

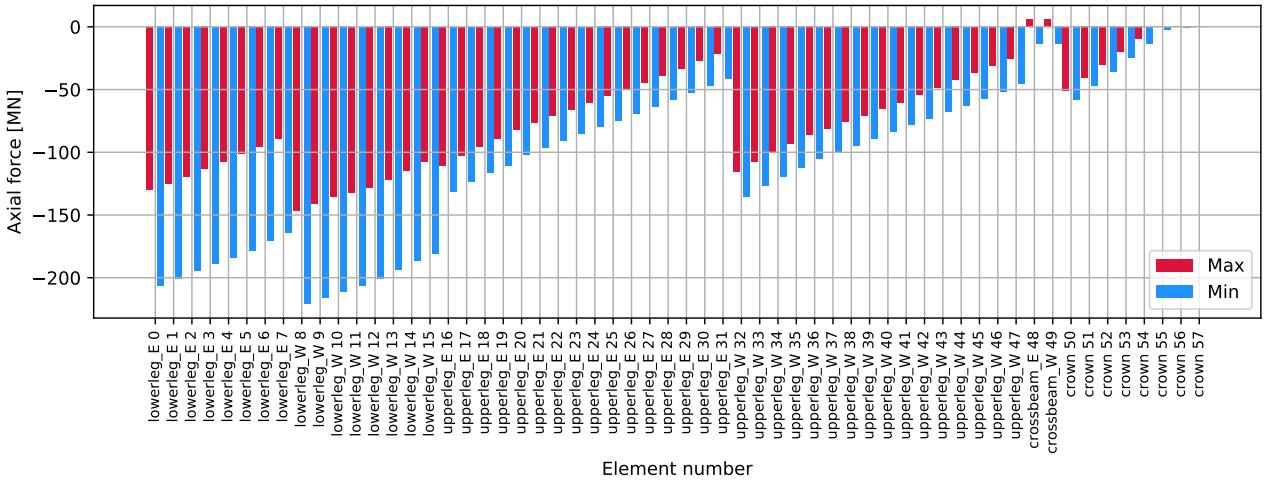

Figure 3.71: P A4 0deg - tower: Axial force [MN]

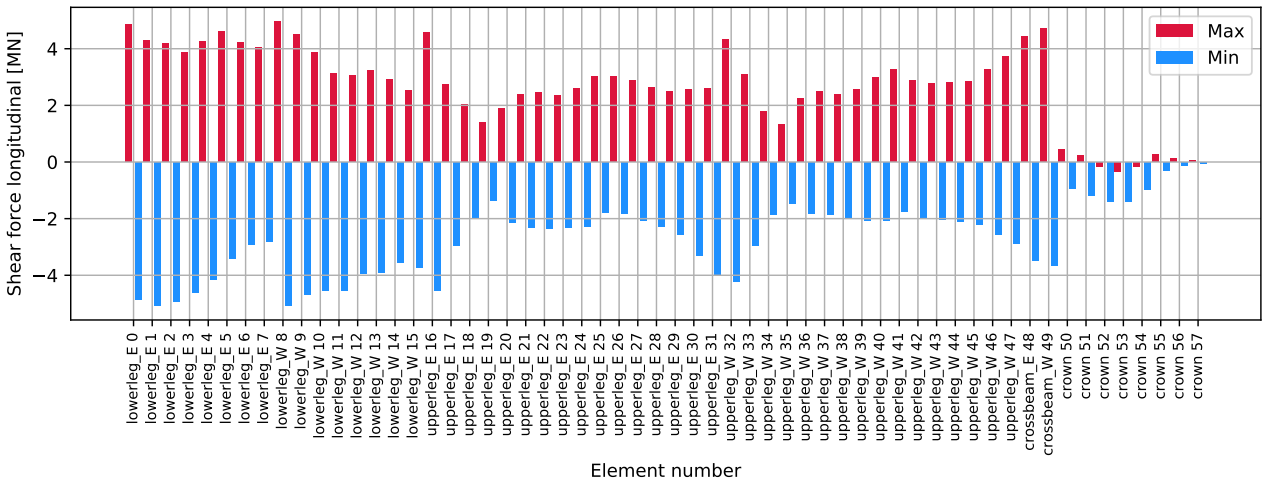

Figure 3.72: P A4 0deg - tower: Shear force longitudinal [MN]

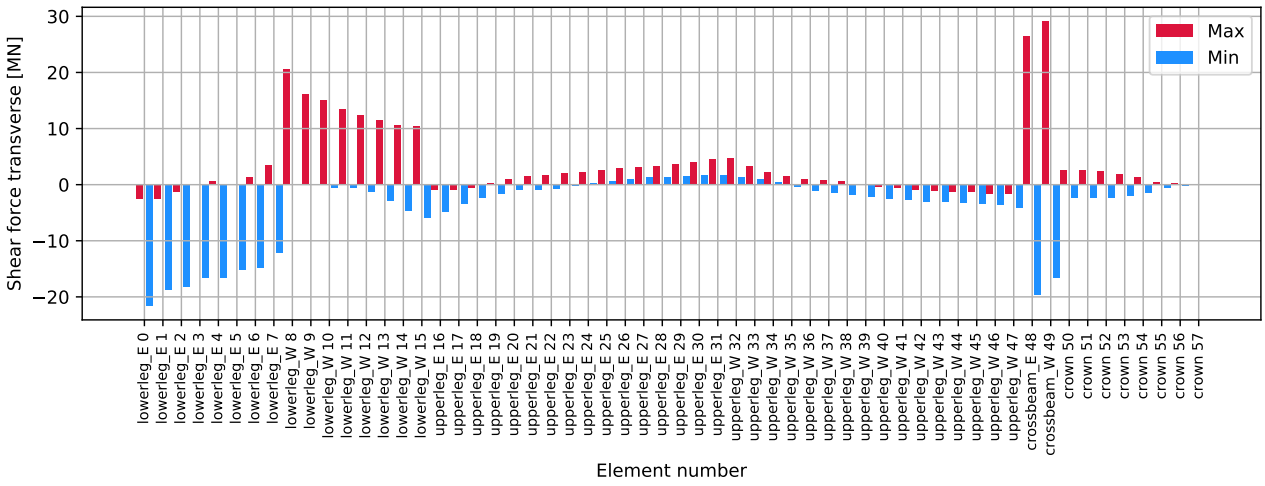

Figure 3.73: P A4 0deg - tower: Shear force transverse [MN]

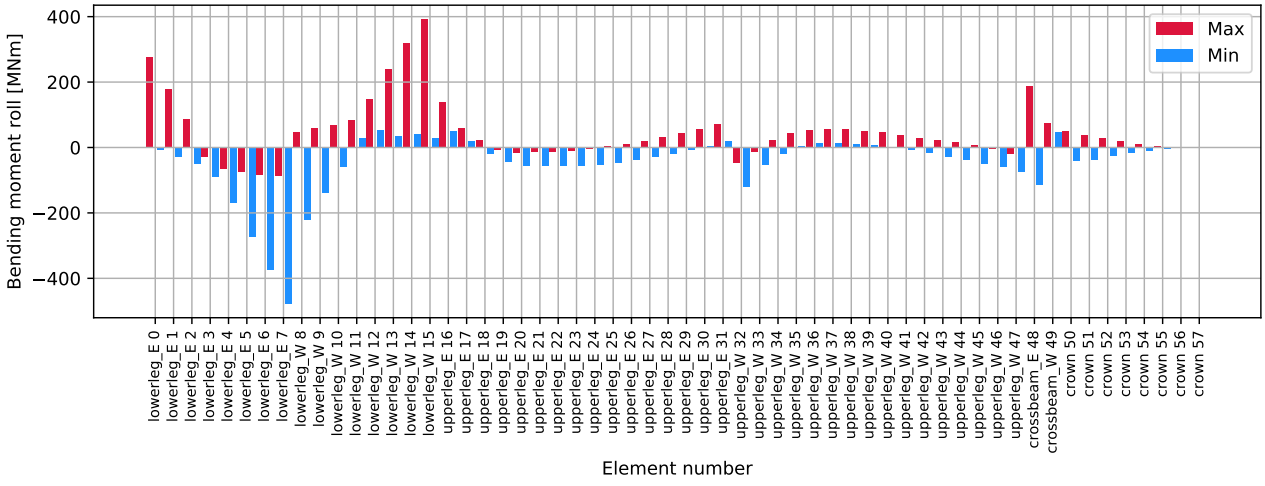

Figure 3.74: P A4 0deg - tower: Bending moment roll [MNm]

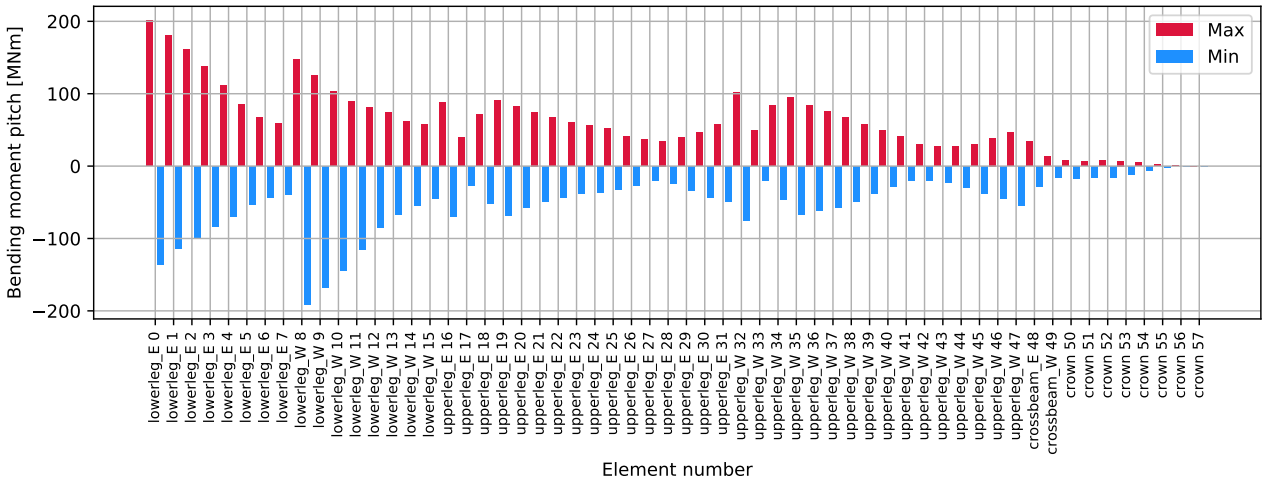

Figure 3.75: P A4 0deg - tower: Bending moment pitch [MNm]

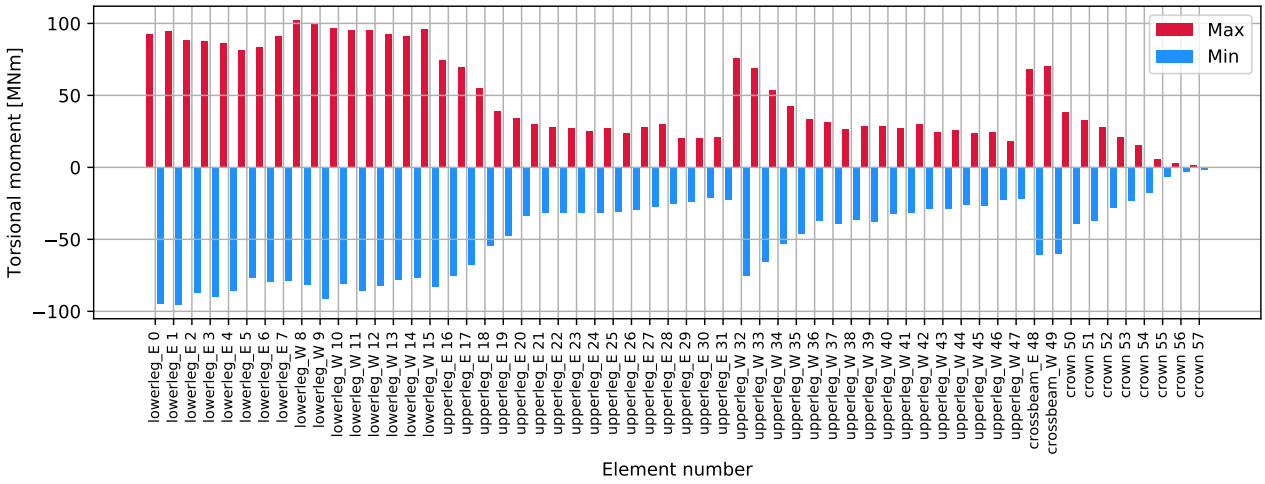

Figure 3.76: P A4 0deg - tower: Torsional moment [MNm]

3.2.3 Time series

Note : Time series are filtered using a Saviotzky-Golay filter for increased readability of the time history plots. Hence, maximum values that occur due to a rapid vibration are not shown in the plots. For maximum values, refer to the tabulated data.
All elements are numbered from South to North, bottom to top

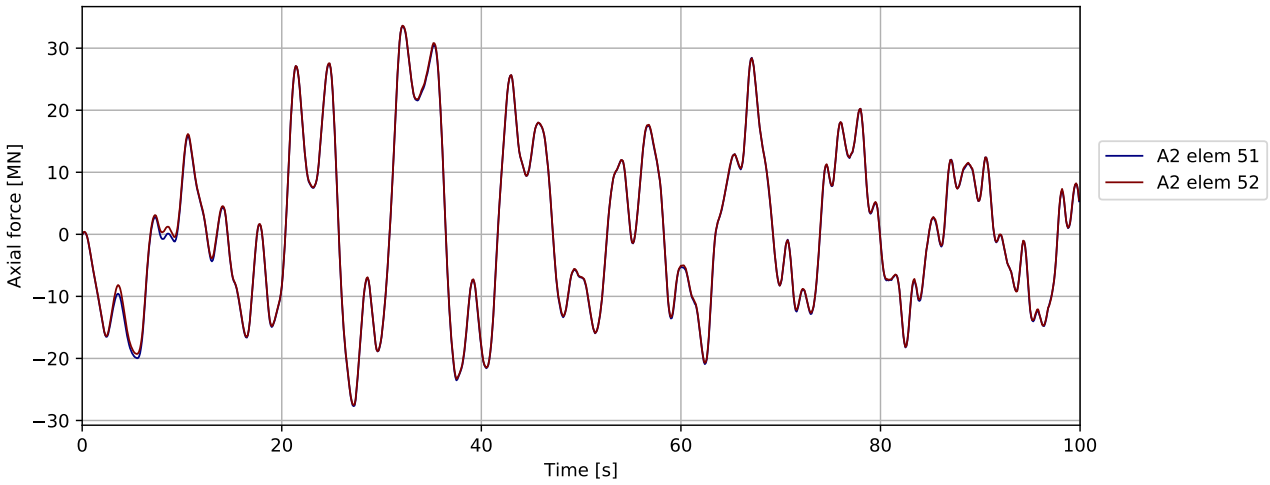

Figure 3.77: P A4 0deg - bridgegirder @ pylon: Axial force [MN]

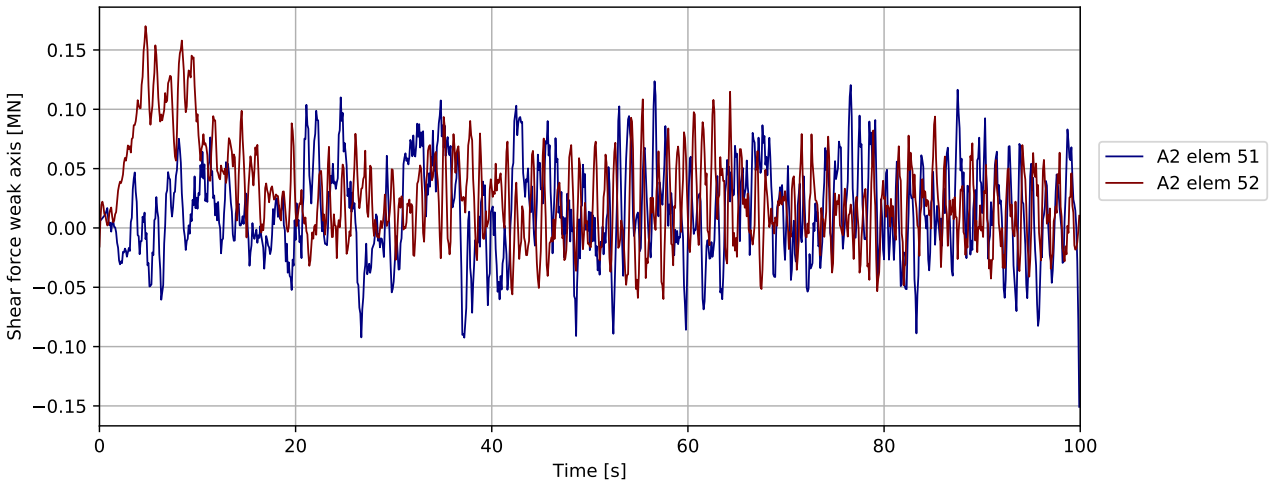

Figure 3.78: P A4 0deg - bridgegirder @ pylon: Shear force weak axis [MN]

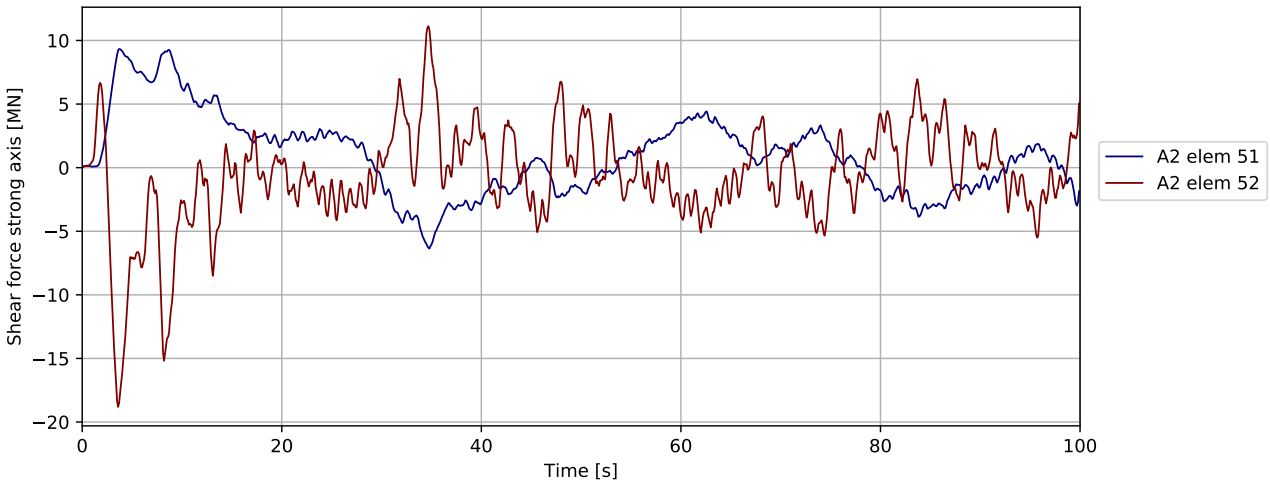

Figure 3.79: P A4 0deg - bridgegirder @ pylon: Shear force strong axis [MN]

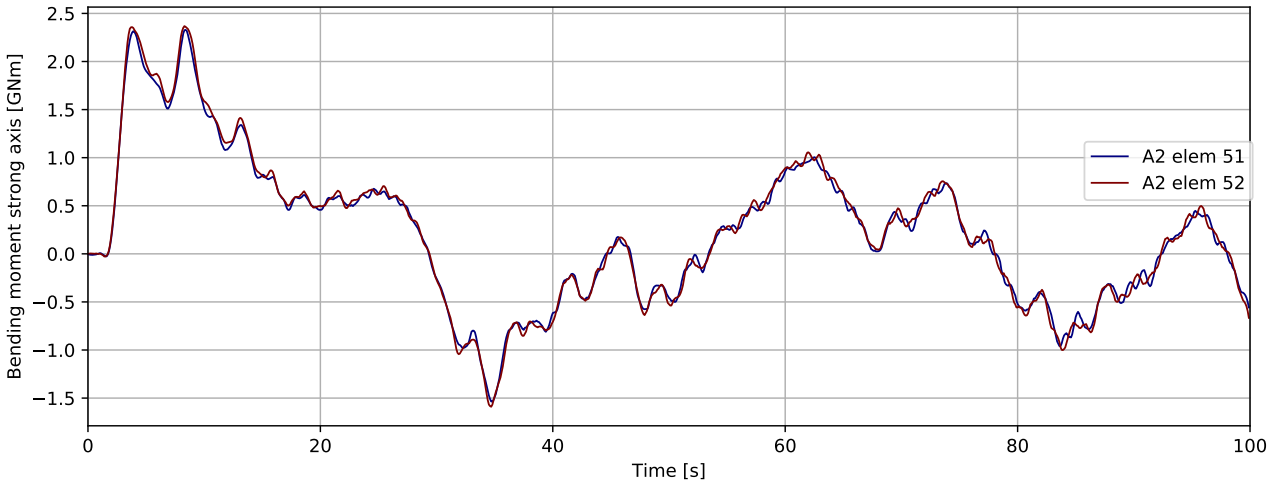

Figure 3.80: P A4 0deg - bridgegirder @ pylon: Bending moment strong axis [GNm]

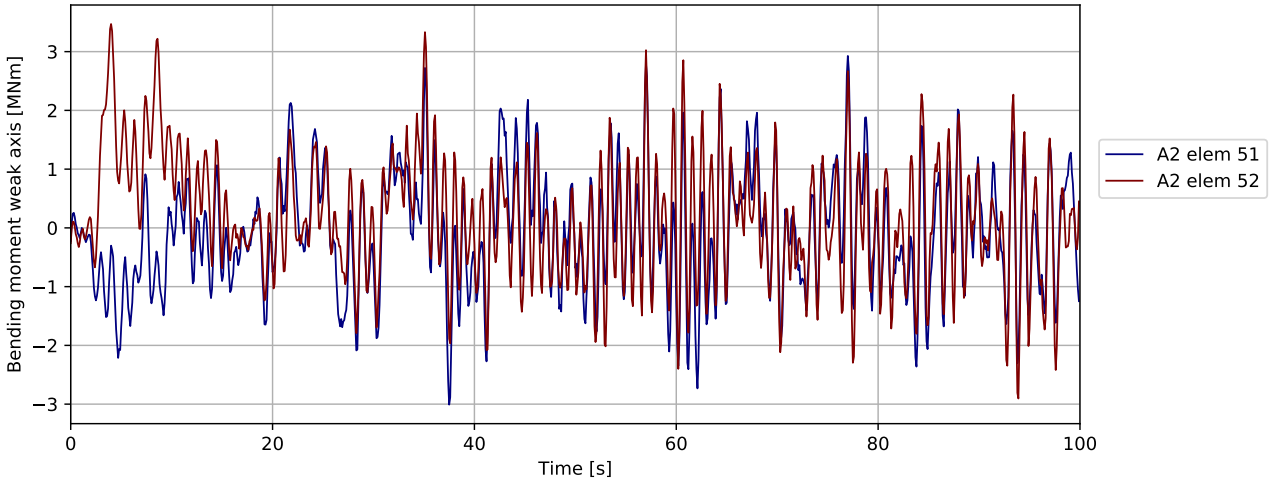

Figure 3.81: P A4 0deg - bridgegirder @ pylon: Bending moment weak axis [MNm]

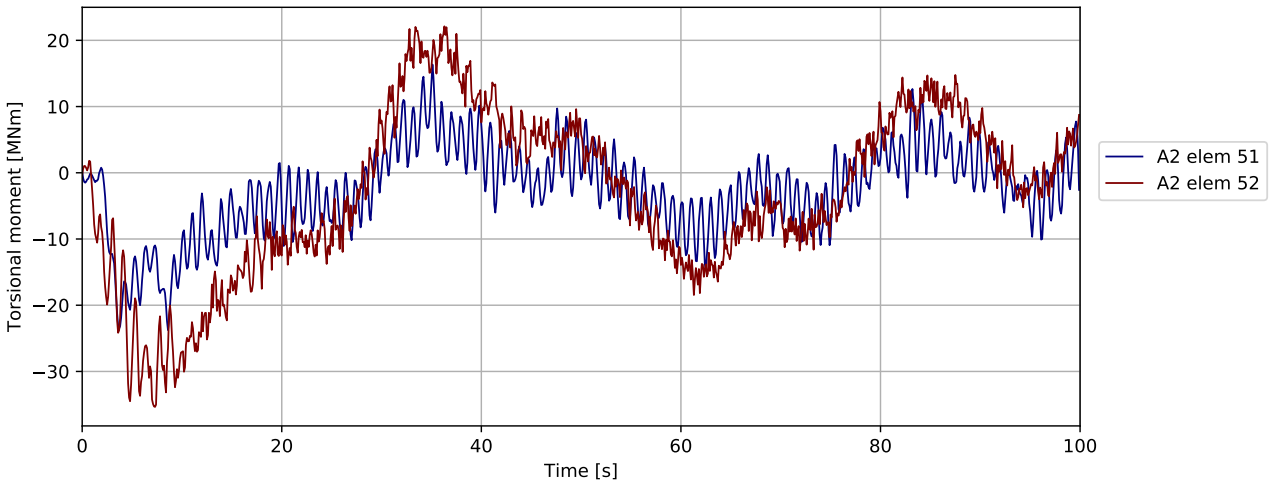

Figure 3.82: P A4 0deg - bridgegirder @ pylon: Torsional moment [MNm]

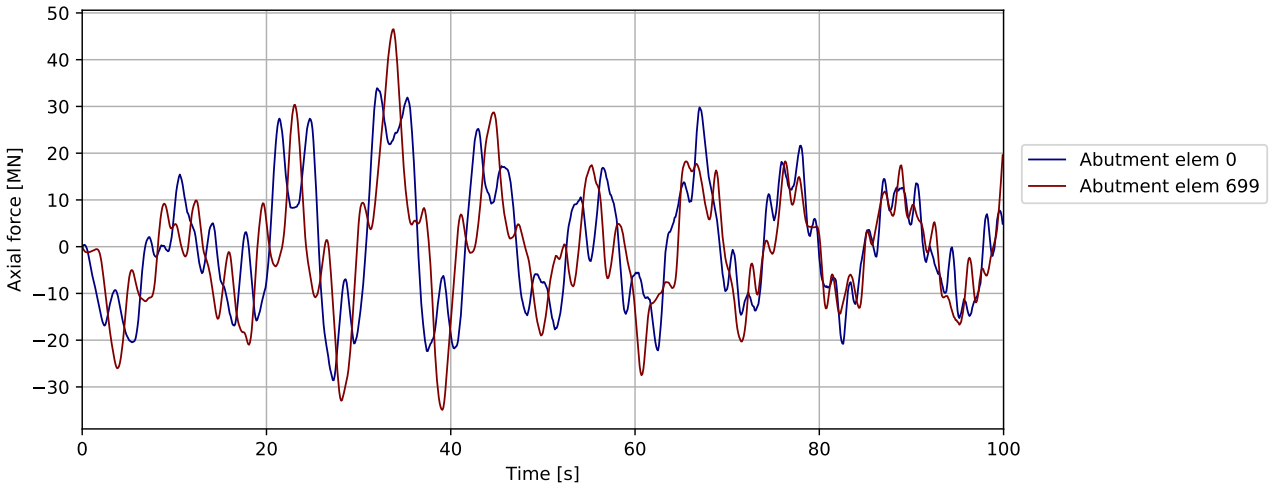

Figure 3.83: P A4 0deg - bridgegirder @abutments: Axial force [MN]

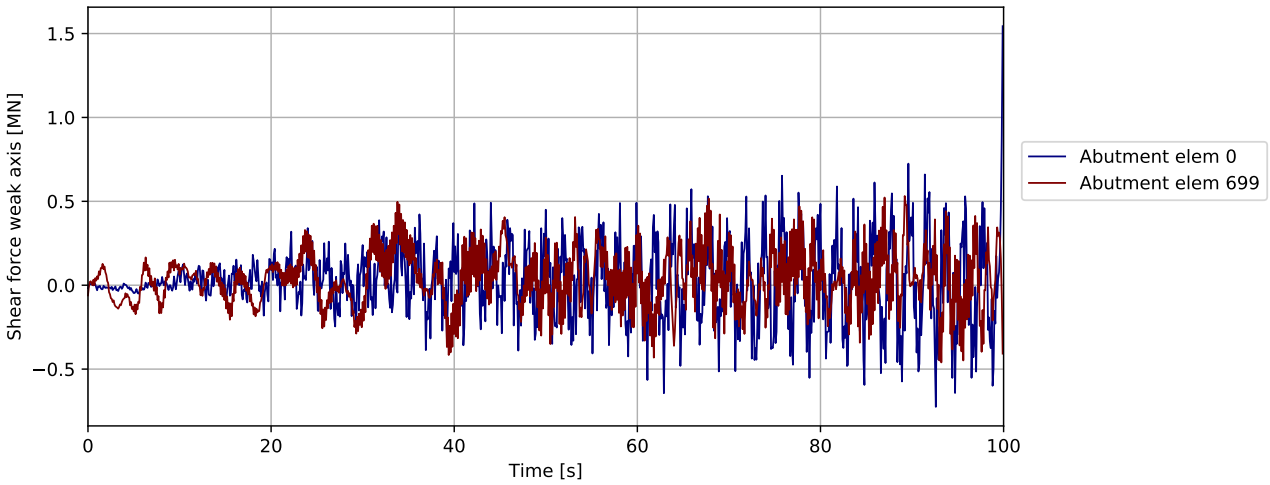

Figure 3.84: P A4 0deg - bridgegirder @abutments: Shear force weak axis [MN]

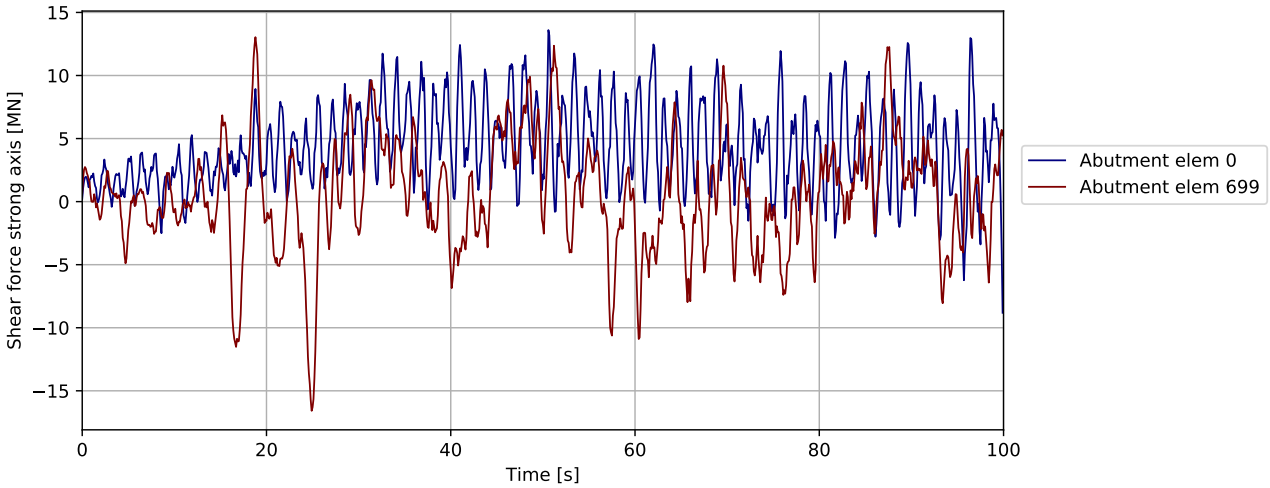

Figure 3.85: P A4 0deg - bridgegirder @abutments: Shear force strong axis [MN]

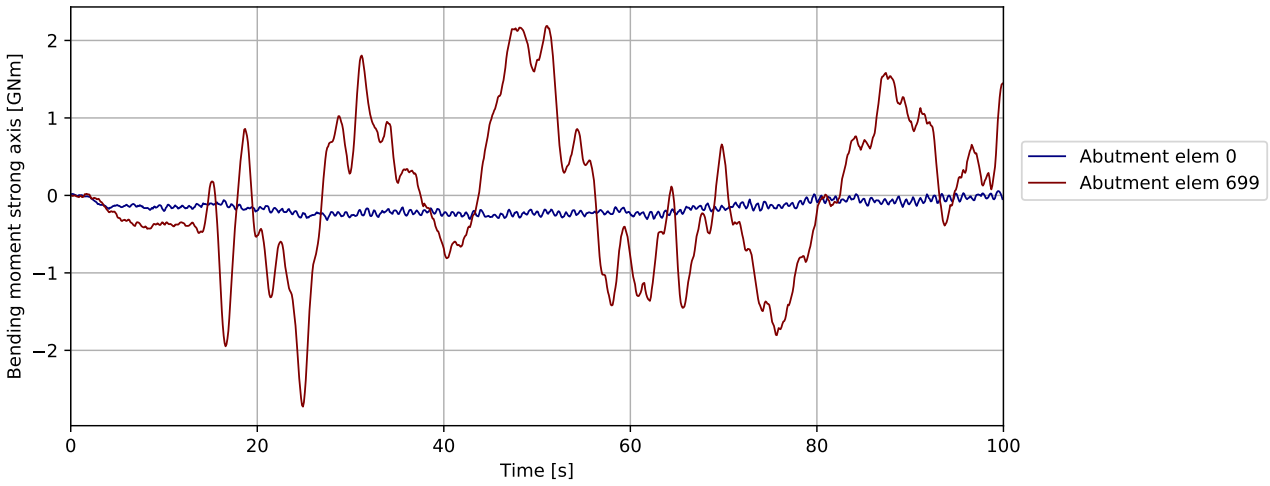

Figure 3.86: P A4 0deg - bridgegirder @abutments: Bending moment strong axis [GNm]

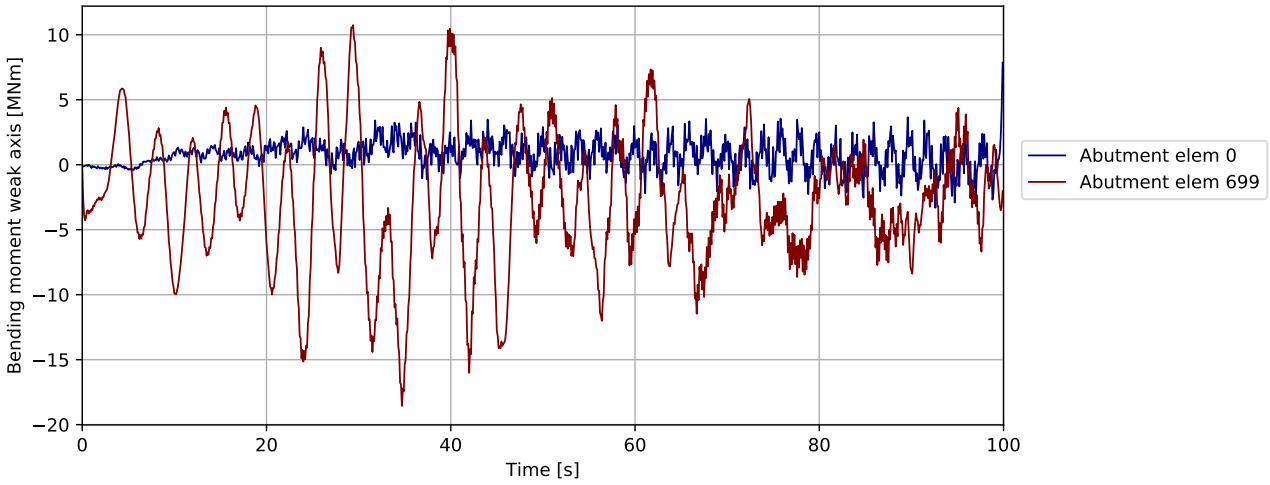

Figure 3.87: P A4 0deg - bridgegirder @abutments: Bending moment weak axis [MNm]

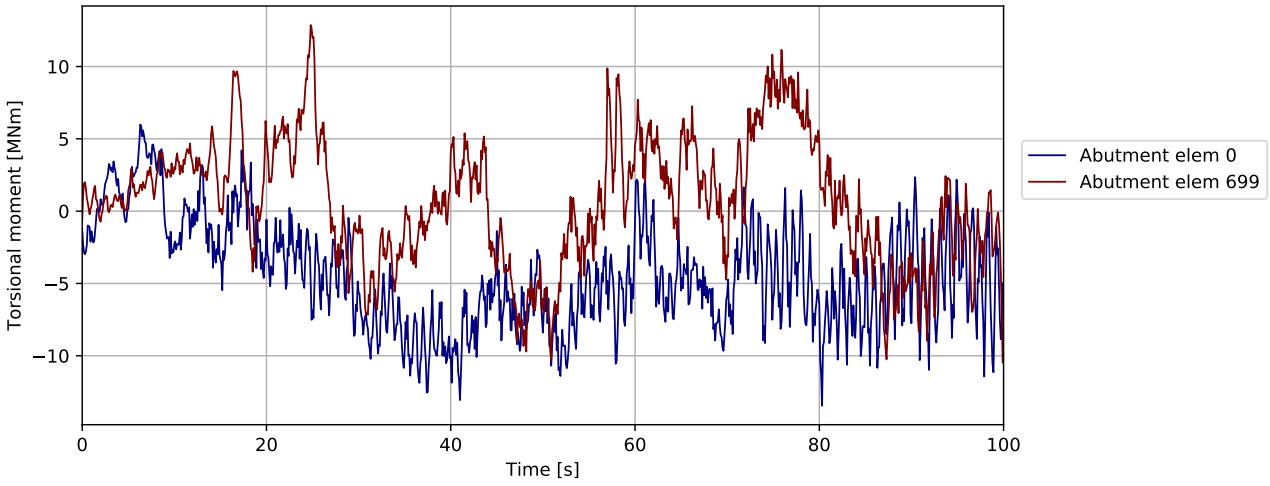

Figure 3.88: P A4 0deg - bridgegirder @abutments: Torsional moment [MNm]

Note : Compressive spring force is negative

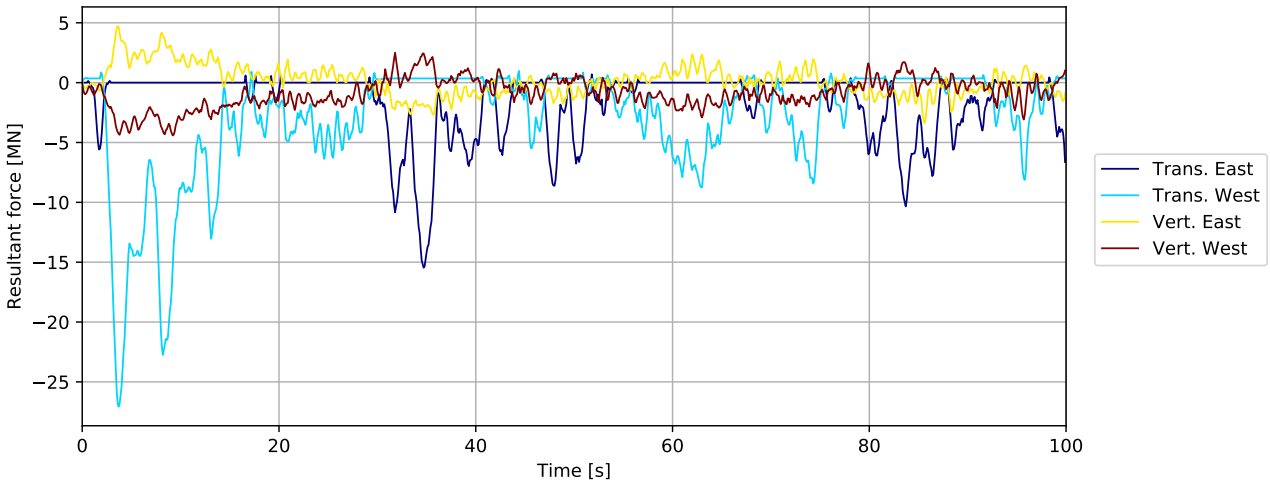

Figure 3.89: P A4 0deg - bridgegirder supports in tower: Resultant force [MN]

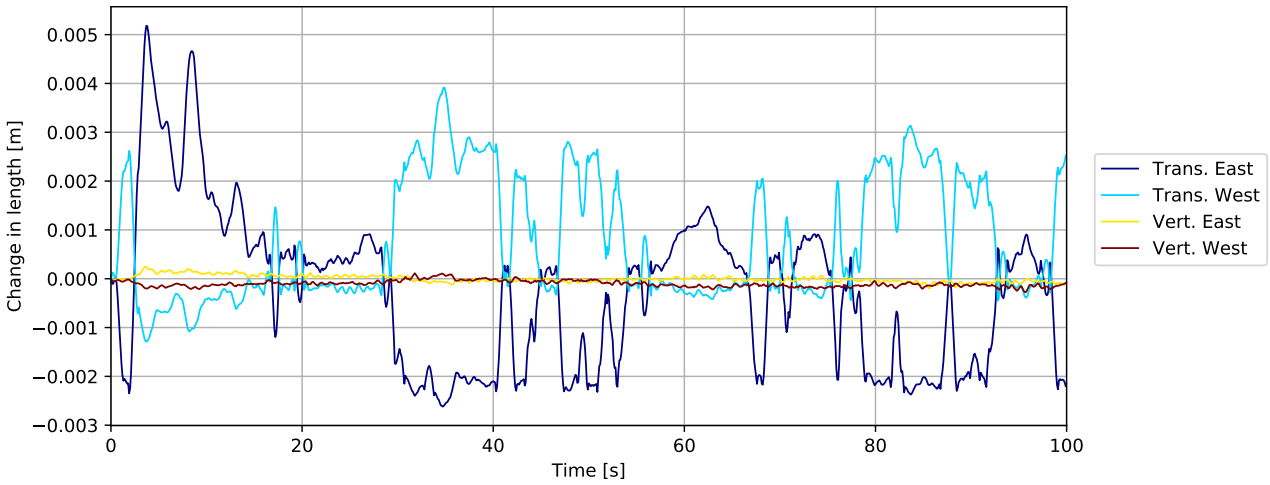

Figure 3.90: P A4 0deg - bridgegirder supports in tower: Change in length [m]

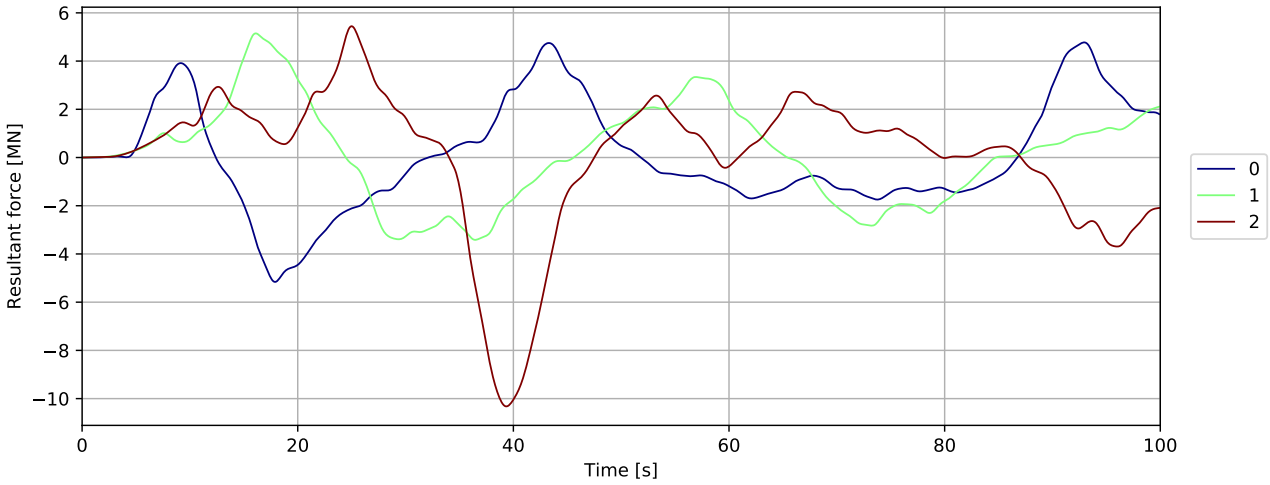

Figure 3.91: Mooring force

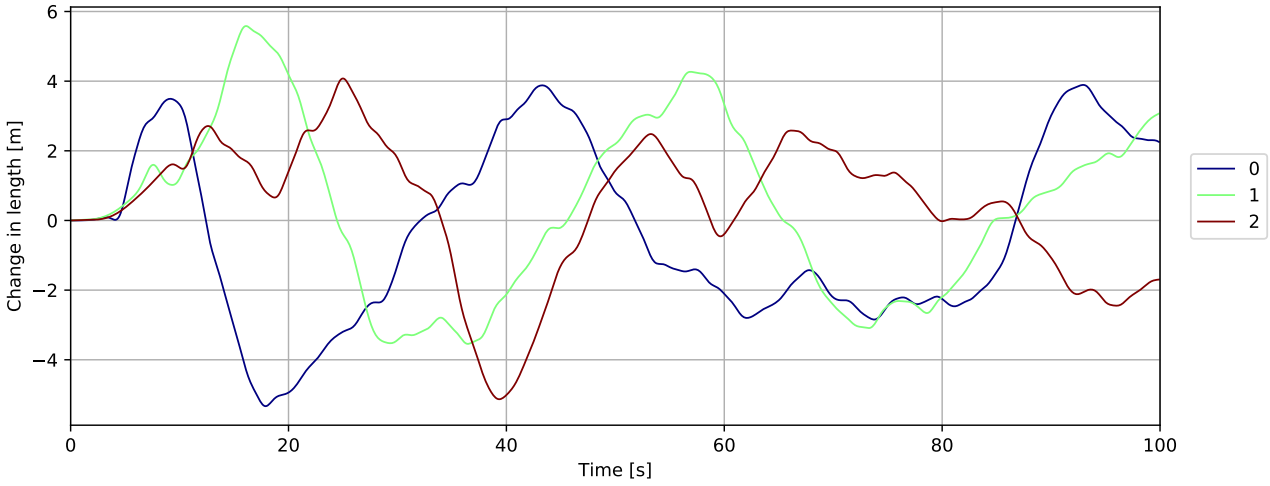

Figure 3.92: Mooring displacement

3.3 PontoonA5 0deg

3.3.1 Overall response

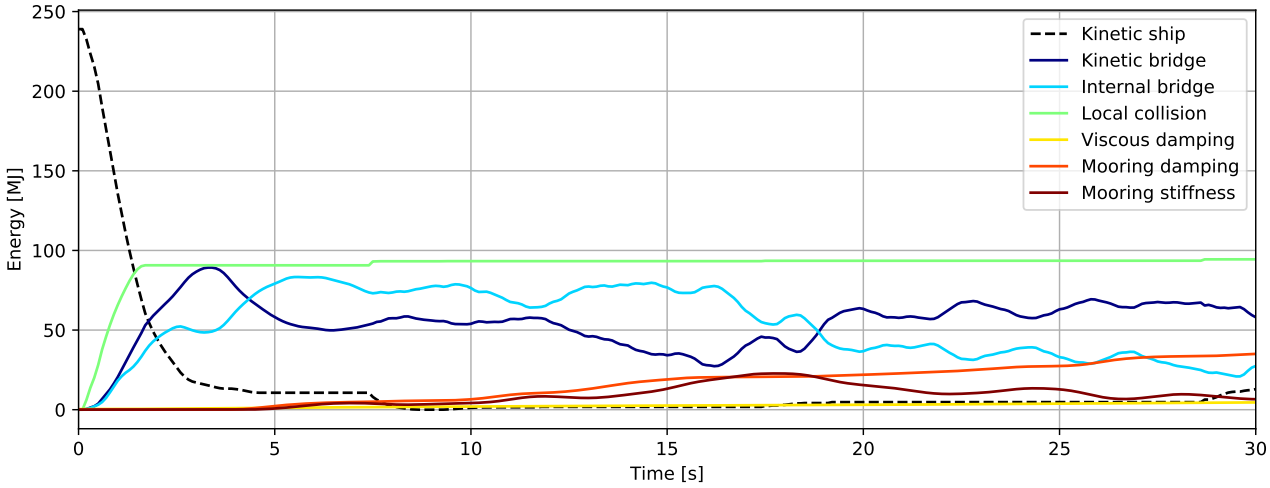

Figure 3.93: Energy [MJ] - initial phase

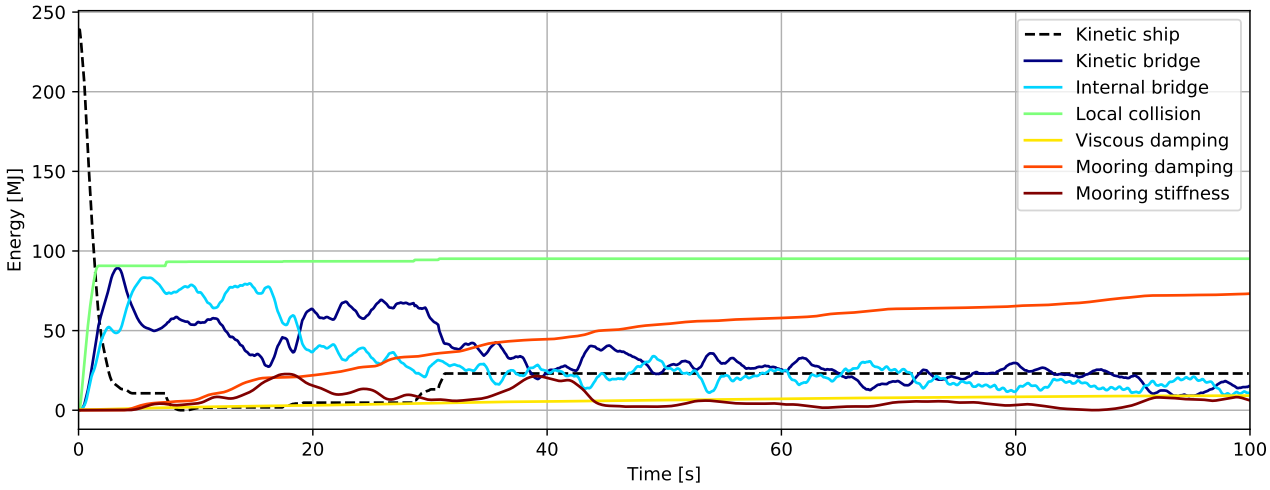

Figure 3.94: Energy [MJ]

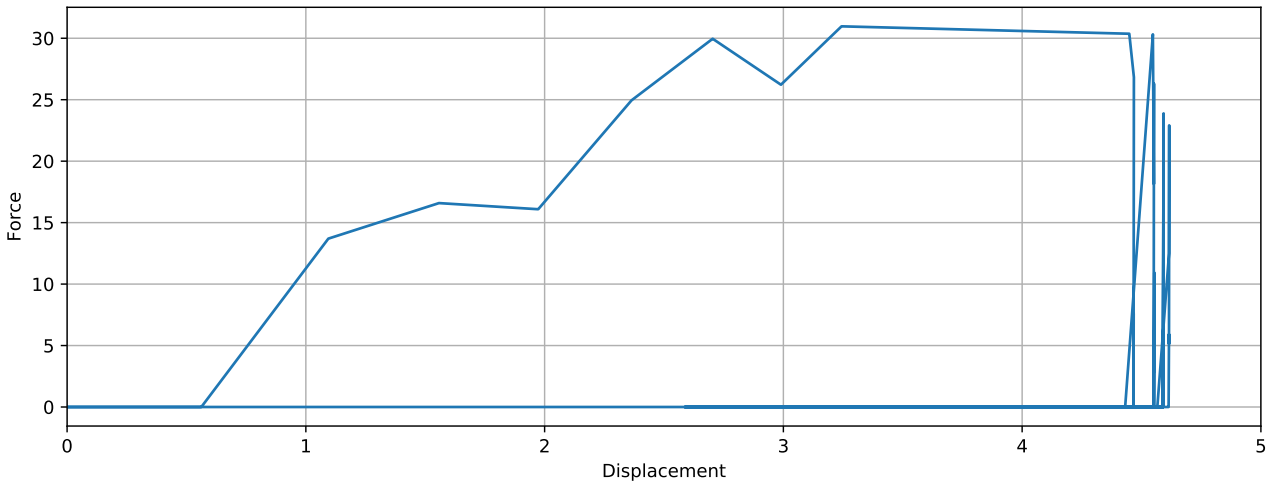

Figure 3.95: Simulated local collision force-displacement

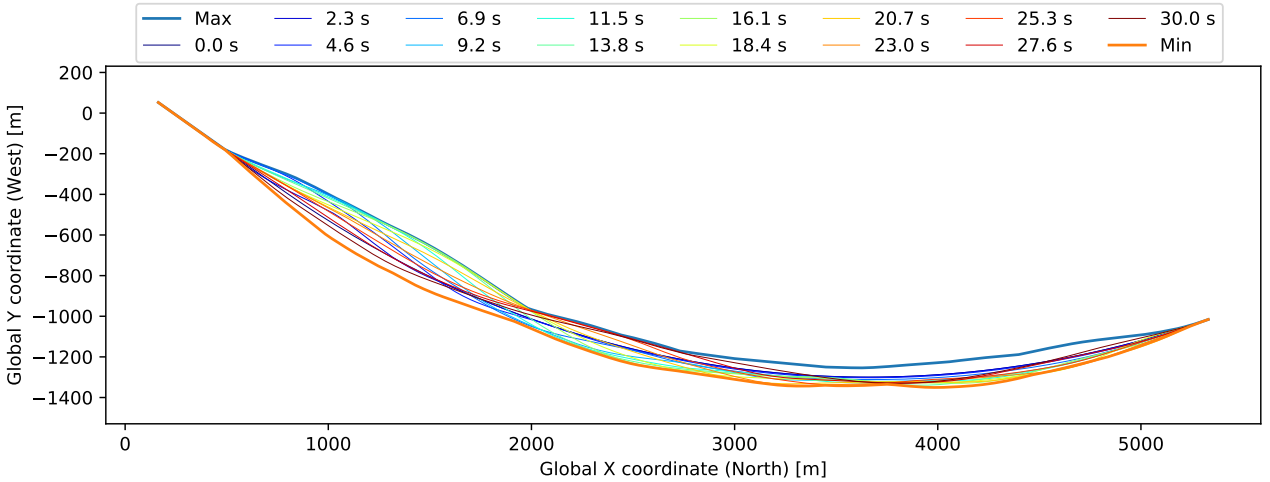

Figure 3.96: Bridgegirder deflection (10x displacment scaling)

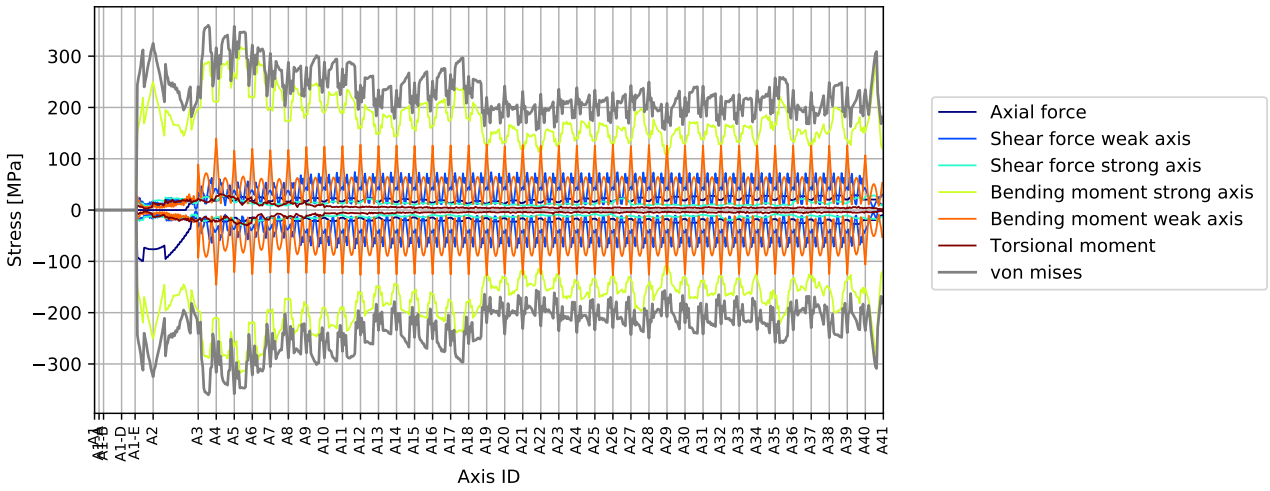

Figure 3.97: Stress envelope from all force components

3.3.2 Envelope plots

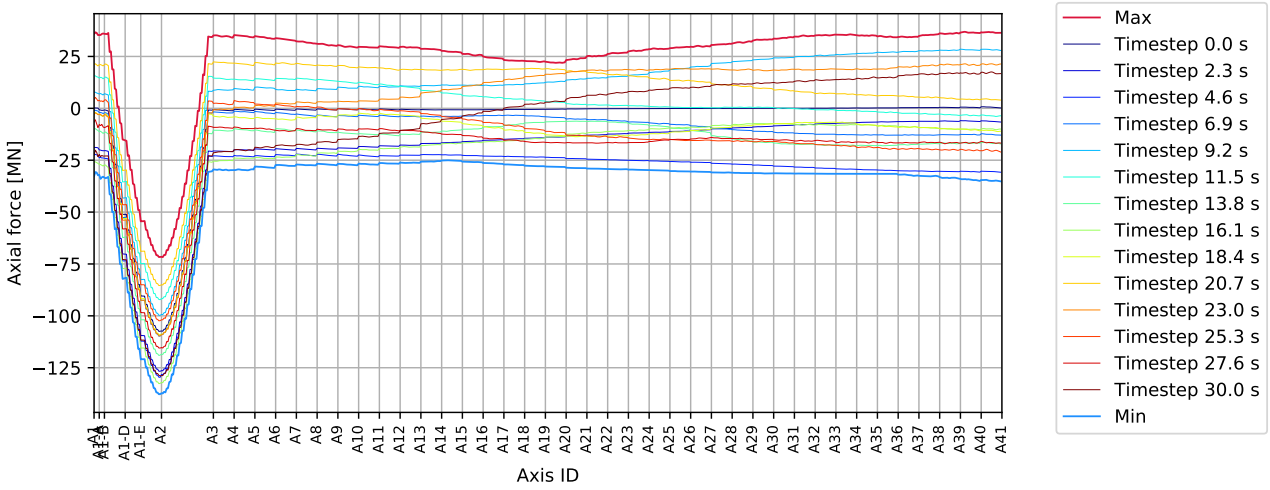

Figure 3.98: P A5 0deg - bridgegirder : Axial force [MN]

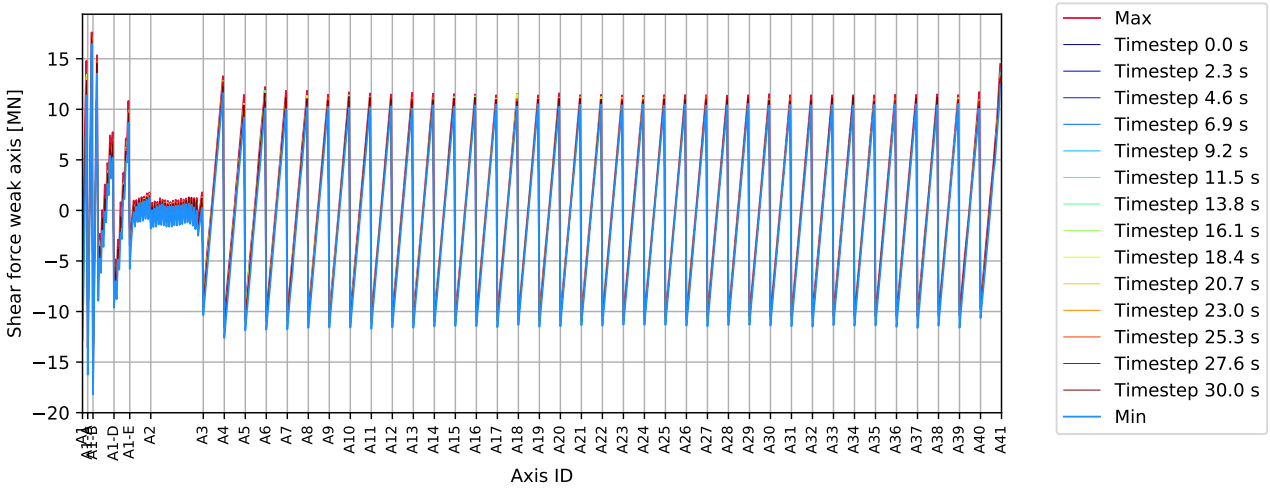

Figure 3.99: P A5 0deg - bridgegirder : Shear force weak axis [MN]

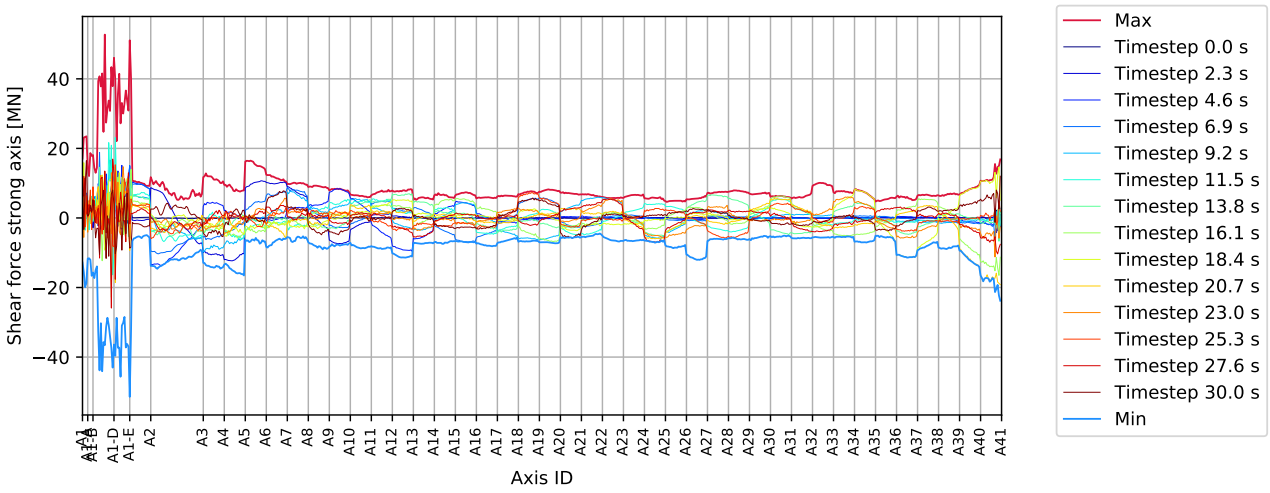

Figure 3.100: P A5 0deg - bridgegirder : Shear force strong axis [MN]

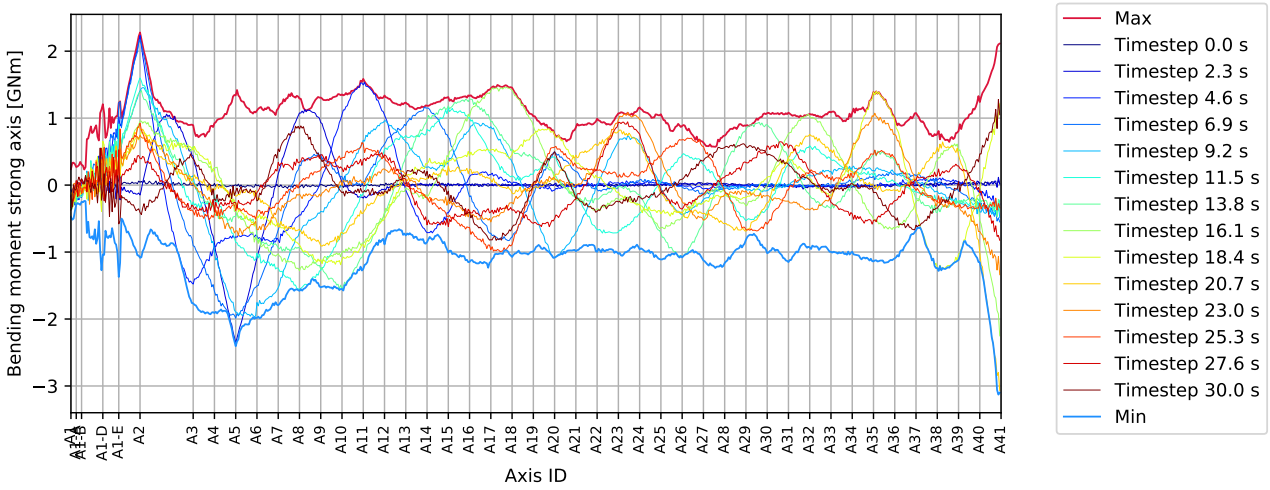

Figure 3.101: P A5 0deg - bridgegirder : Bending moment strong axis [GNm]

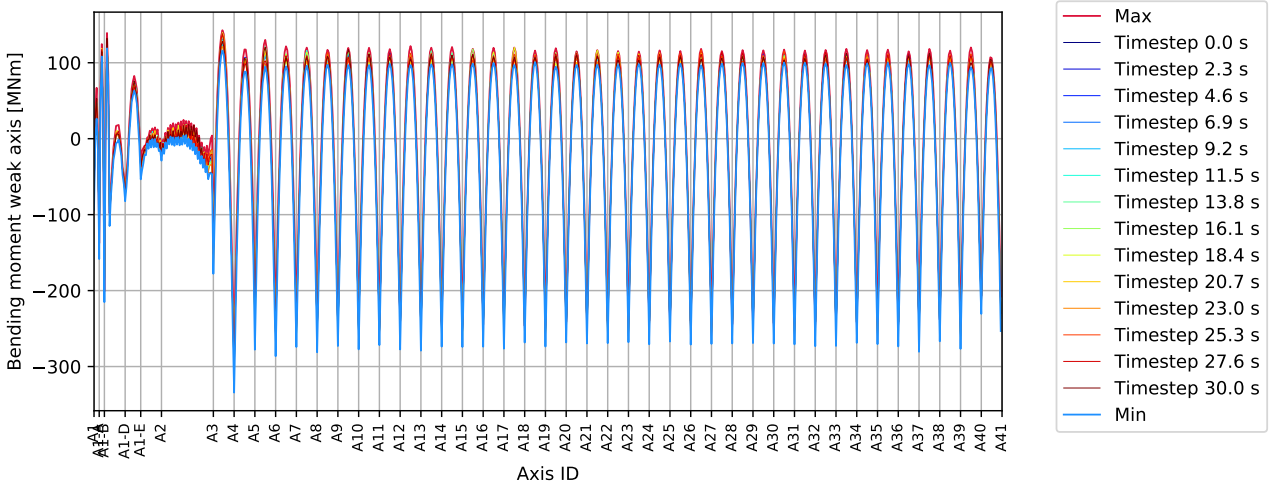

Figure 3.102: P A5 0deg - bridgegirder : Bending moment weak axis [MNm]

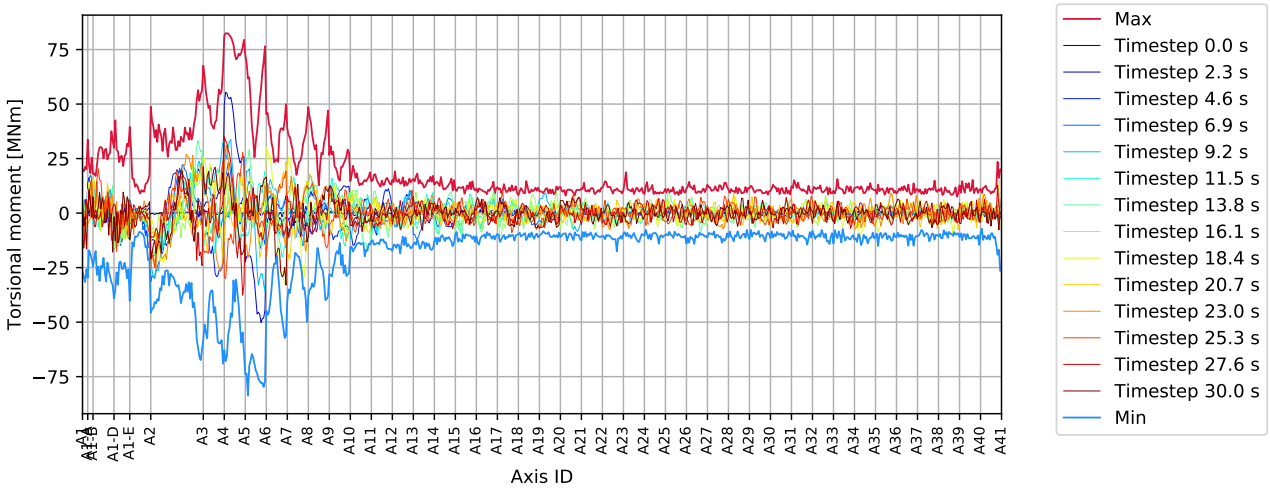

Figure 3.103: P A5 0deg - bridgegirder : Torsional moment [MNm]

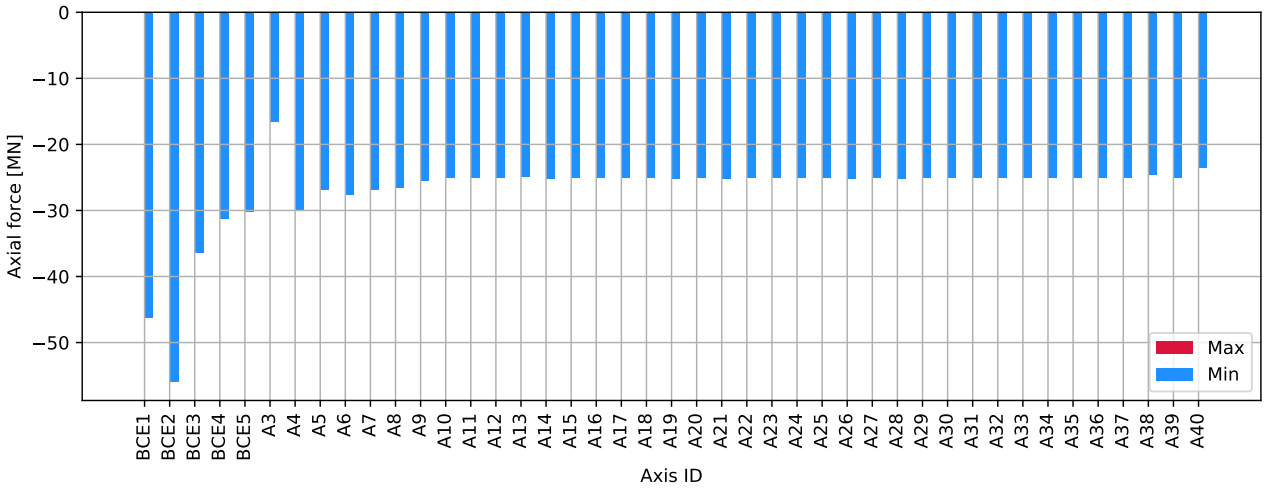

Figure 3.104: P A5 0deg - columns bottom : Axial force [MN]

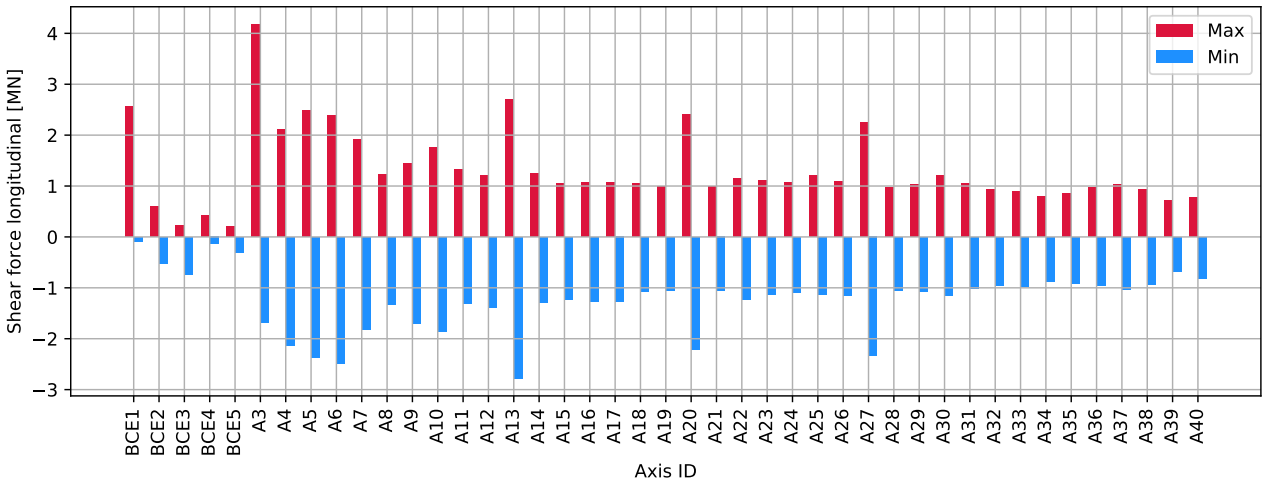

Figure 3.105: P A5 0deg - columns bottom : Shear force longitudinal [MN]

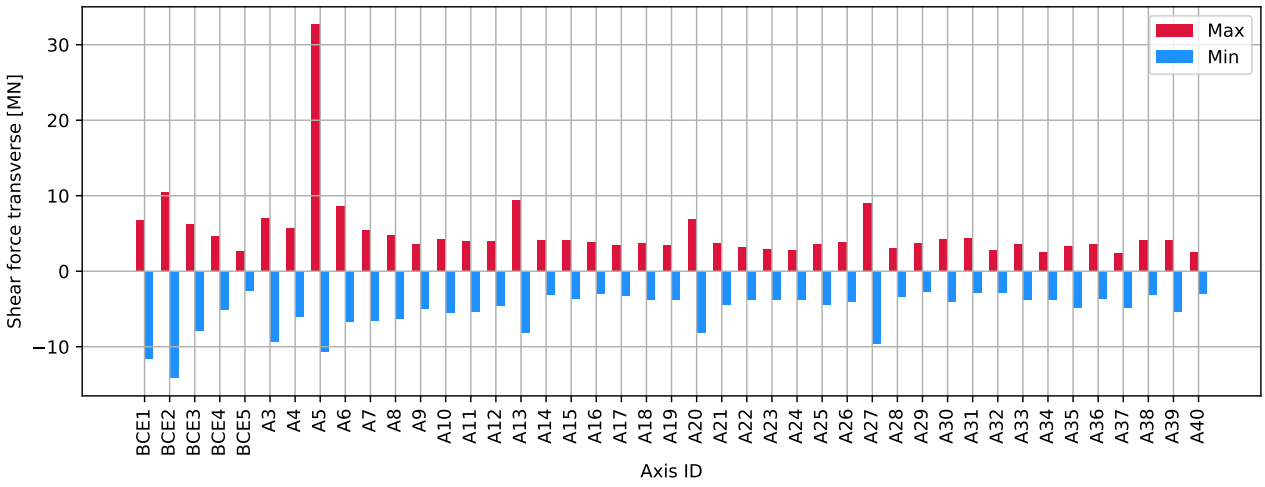

Figure 3.106: P A5 0deg - columns bottom : Shear force transverse [MN]

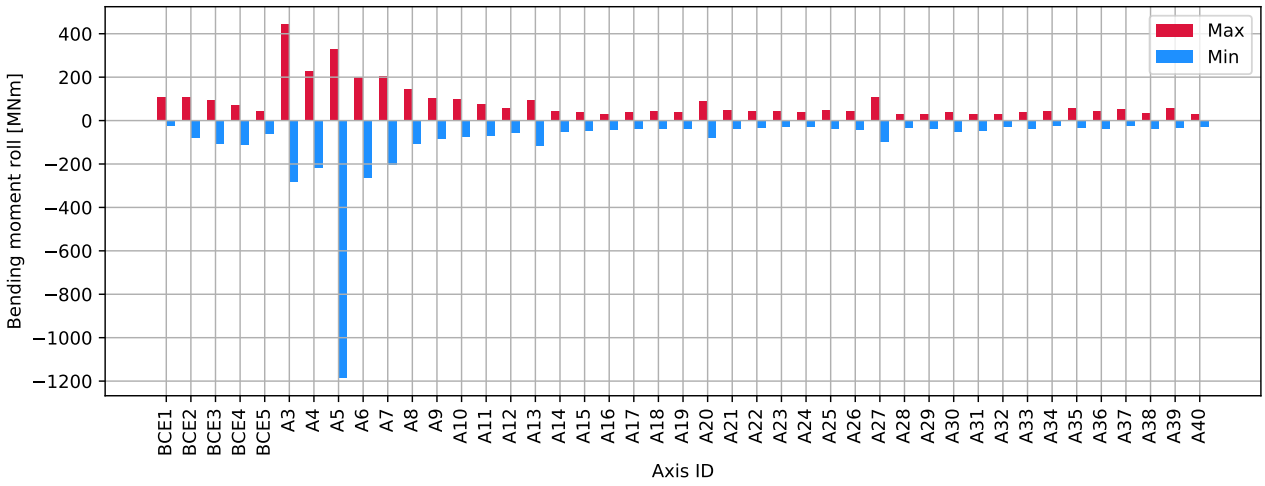

Figure 3.107: P A5 0deg - columns bottom : Bending moment roll [MNm]

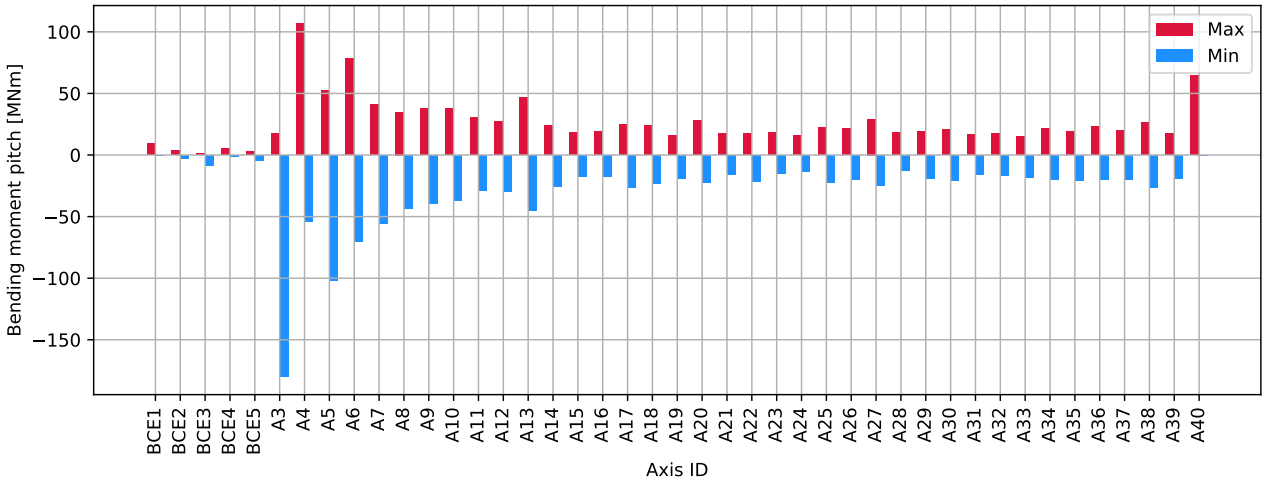

Figure 3.108: P A5 0deg - columns bottom : Bending moment pitch [MNm]

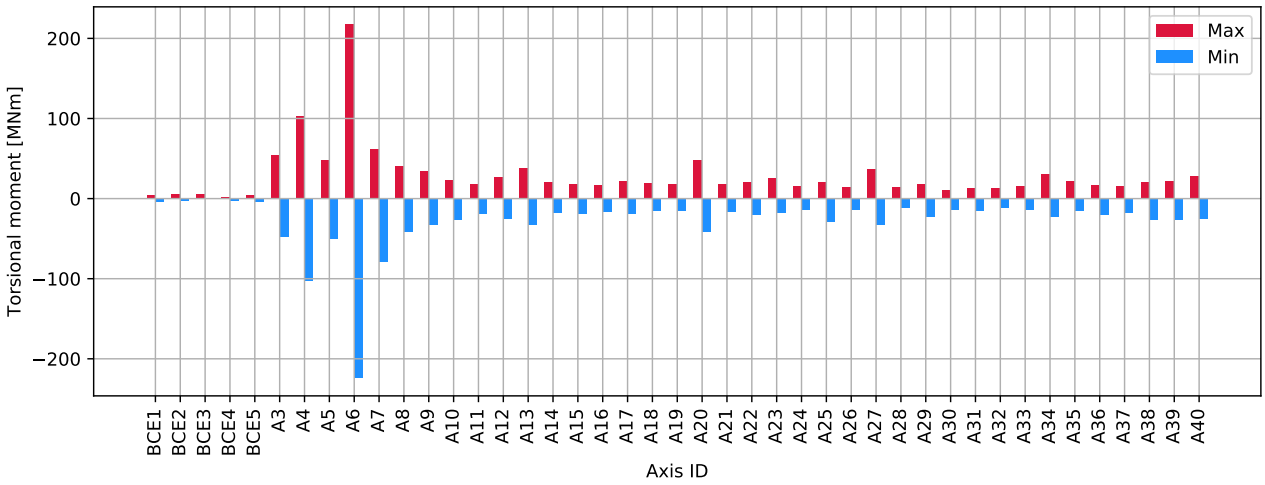

Figure 3.109: P A5 0deg - columns bottom : Torsional moment [MNm]

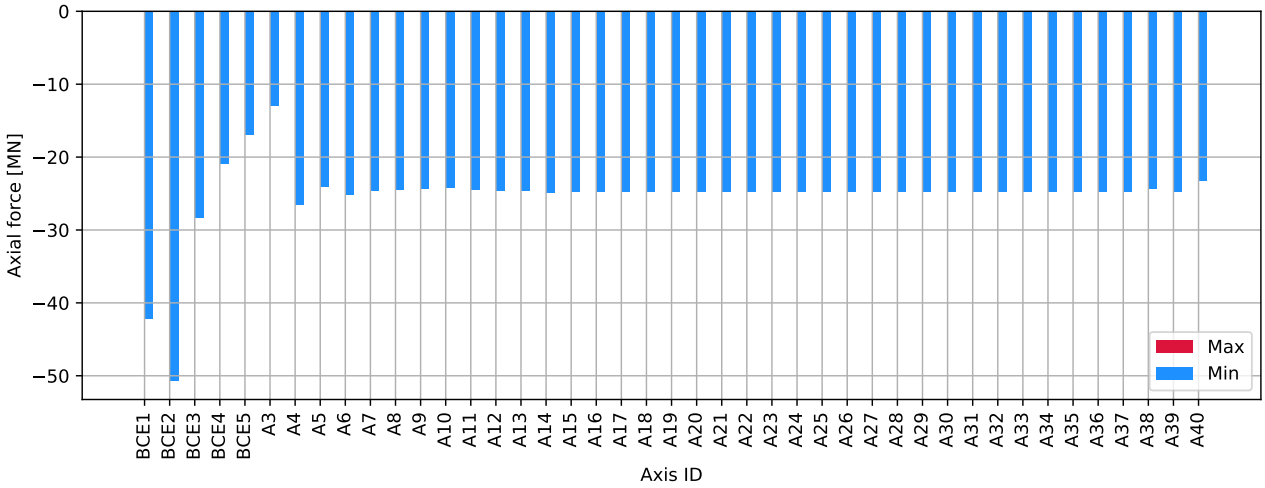

Figure 3.110: P A5 0deg - columns top : Axial force [MN]

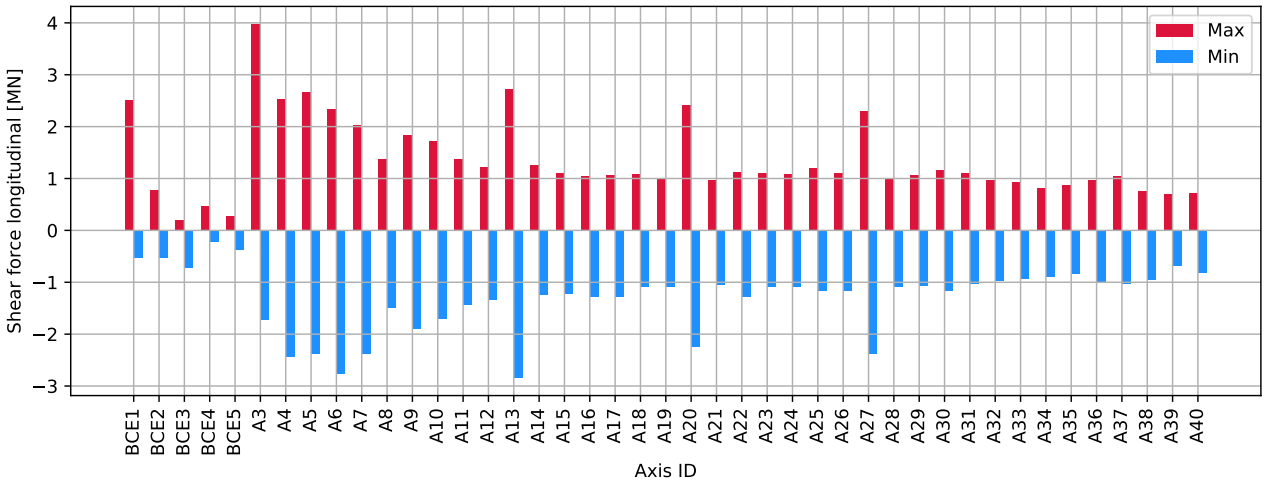

Figure 3.111: P A5 0deg - columns top : Shear force longitudinal [MN]

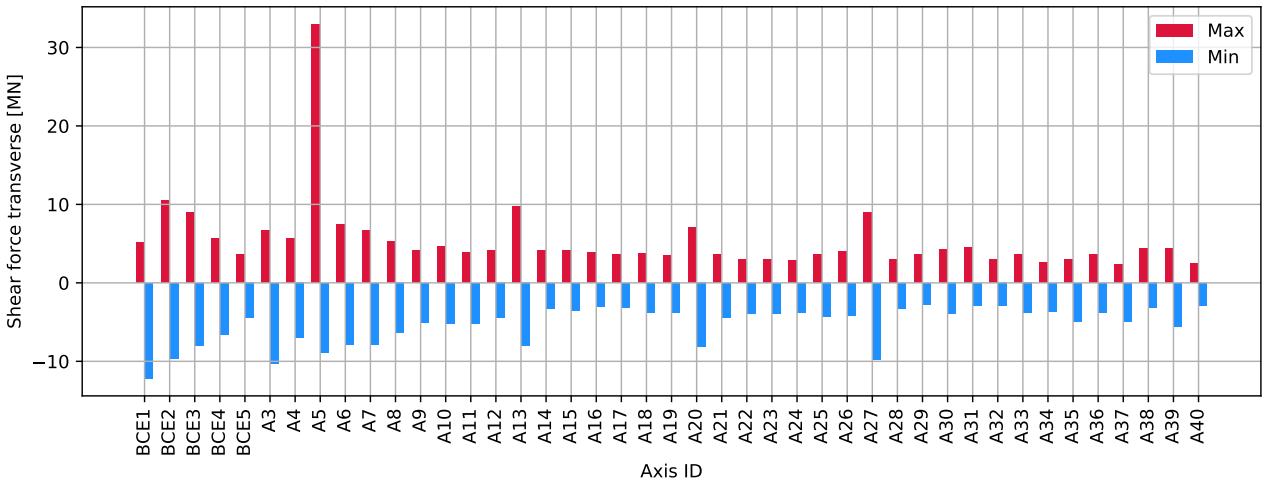

Figure 3.112: P A5 0deg - columns top : Shear force transverse [MN]

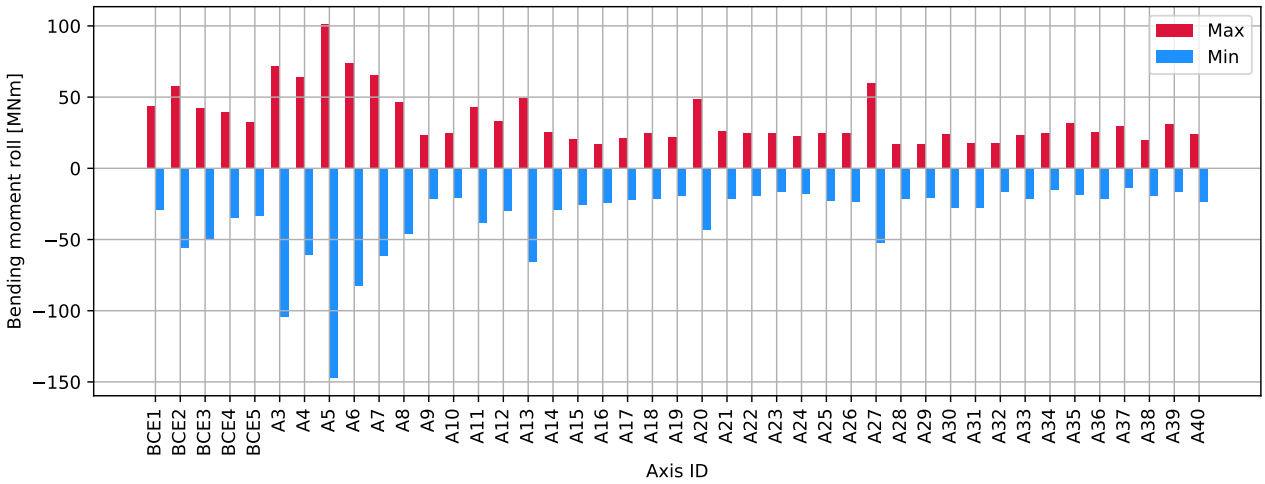

Figure 3.113: P A5 0deg - columns top : Bending moment roll [MNm]

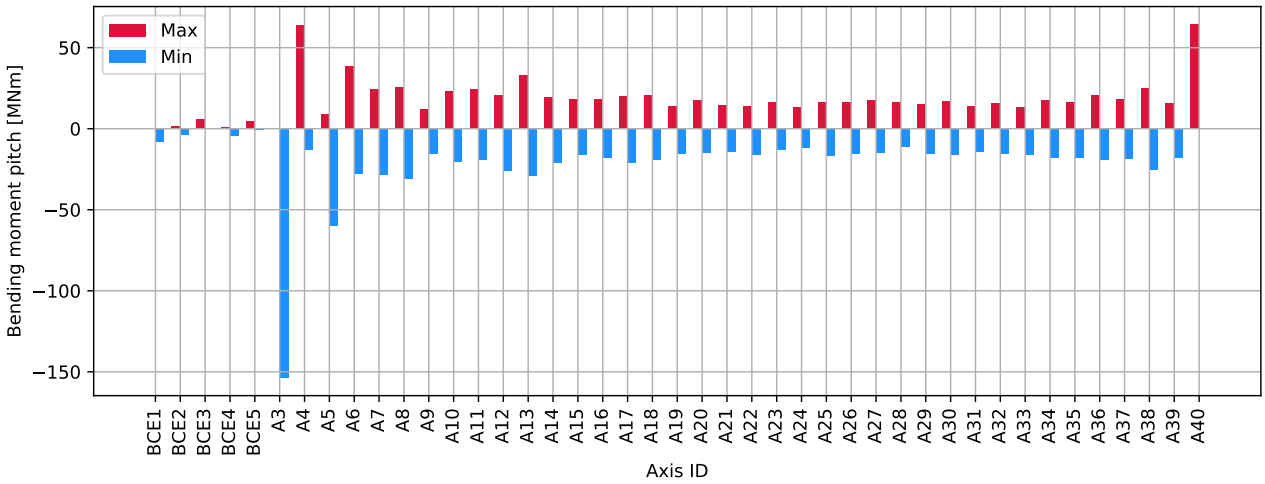

Figure 3.114: P A5 0deg - columns top : Bending moment pitch [MNm]

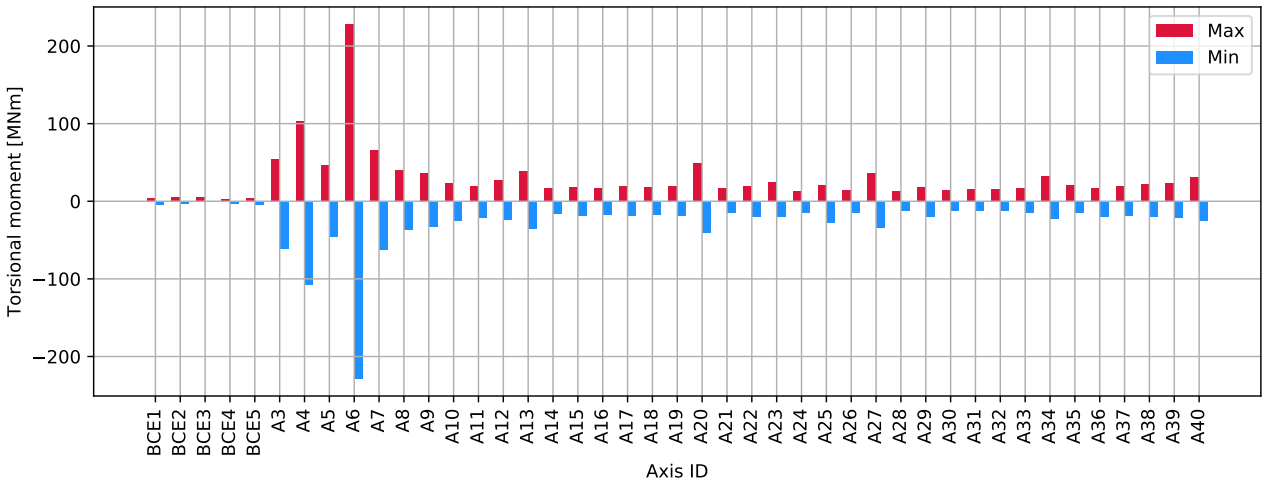

Figure 3.115: P A5 0deg - columns top : Torsional moment [MNm]

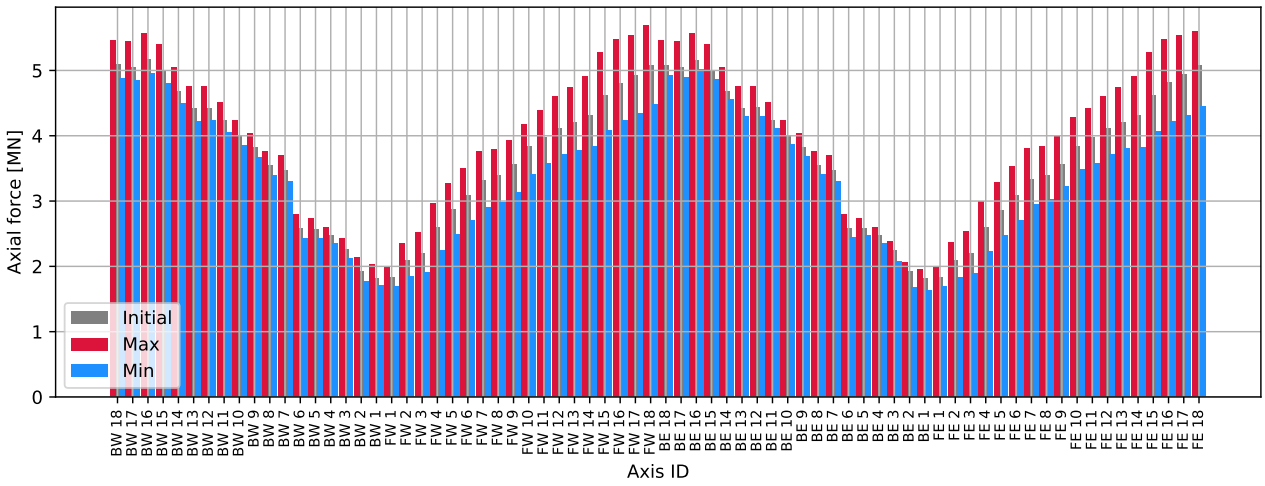

Figure 3.116: P A5 0deg - cables : Axial force [MN]

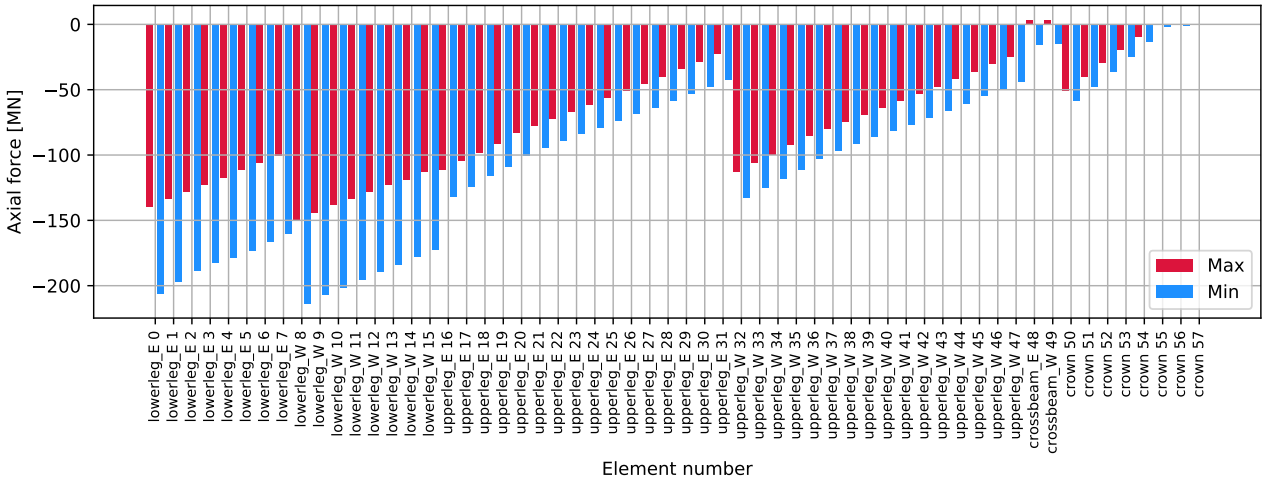

Figure 3.117: P A5 0deg - tower: Axial force [MN]

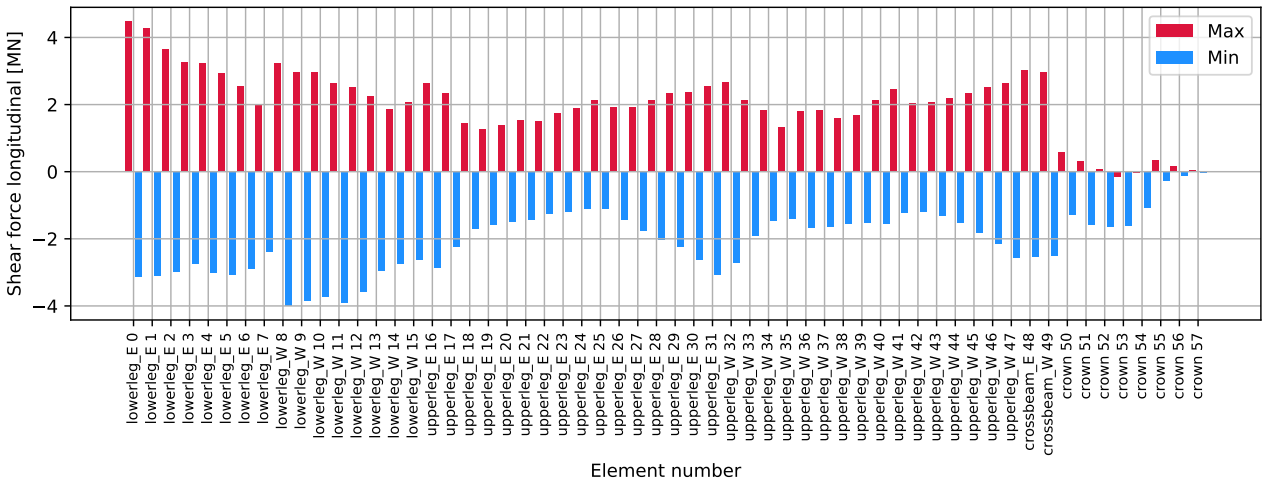

Figure 3.118: P A5 0deg - tower: Shear force longitudinal [MN]

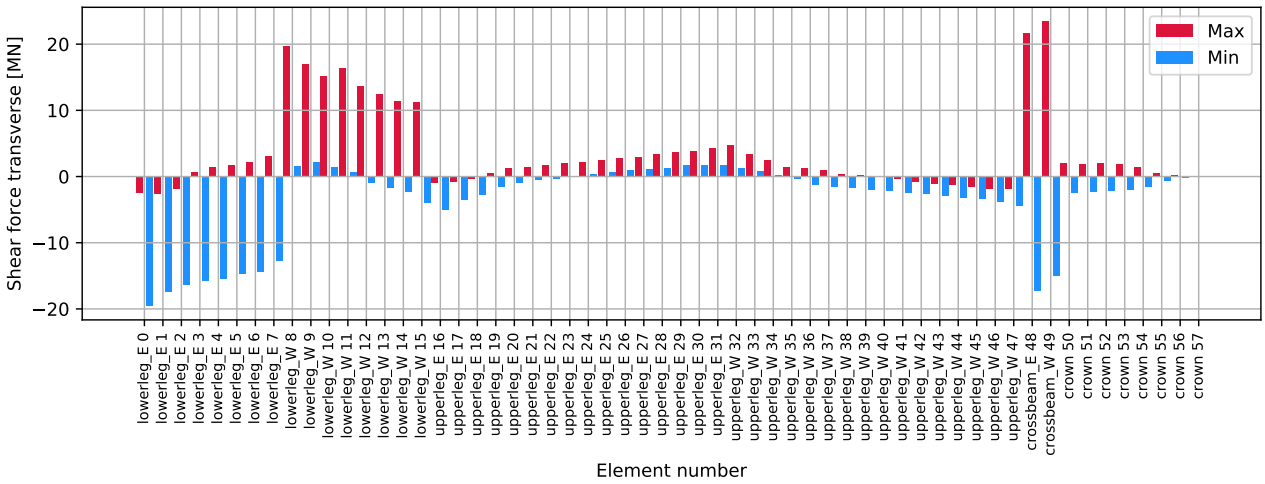

Figure 3.119: P A5 0deg - tower: Shear force transverse [MN]

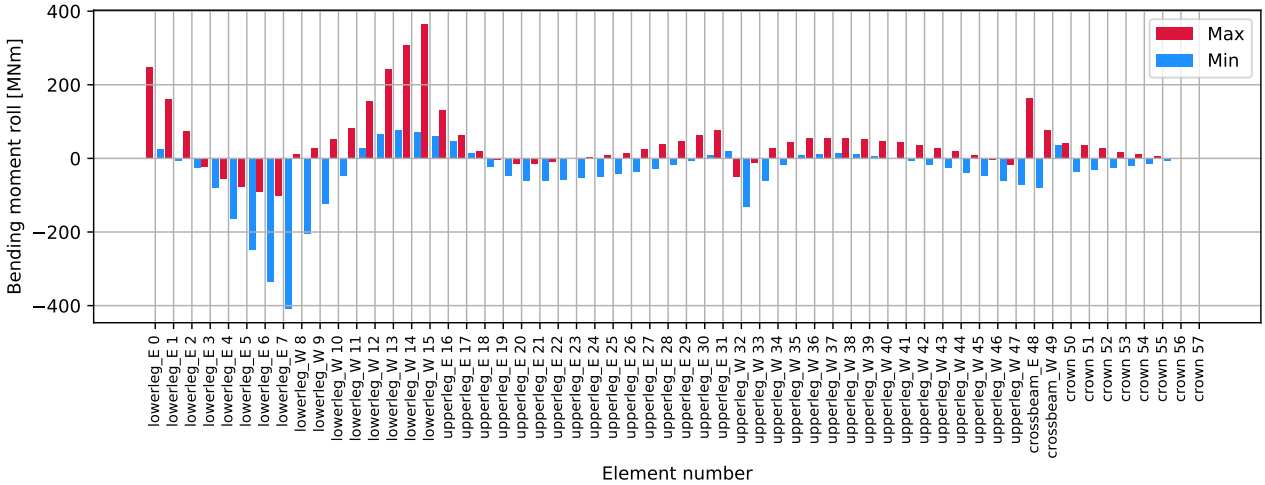

Figure 3.120: P A5 0deg - tower: Bending moment roll [MNm]

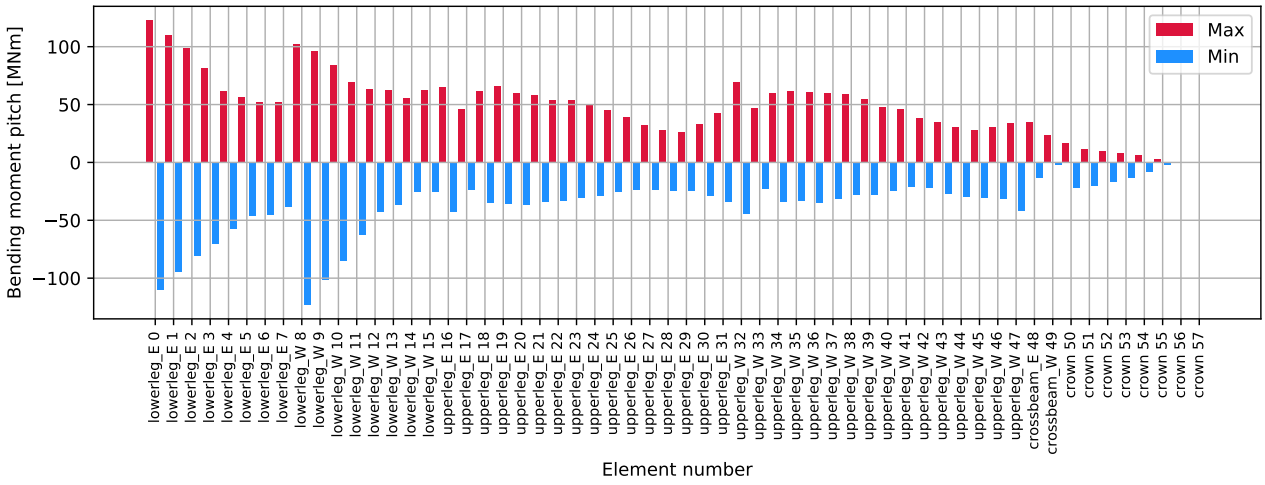

Figure 3.121: P A5 0deg - tower: Bending moment pitch [MNm]

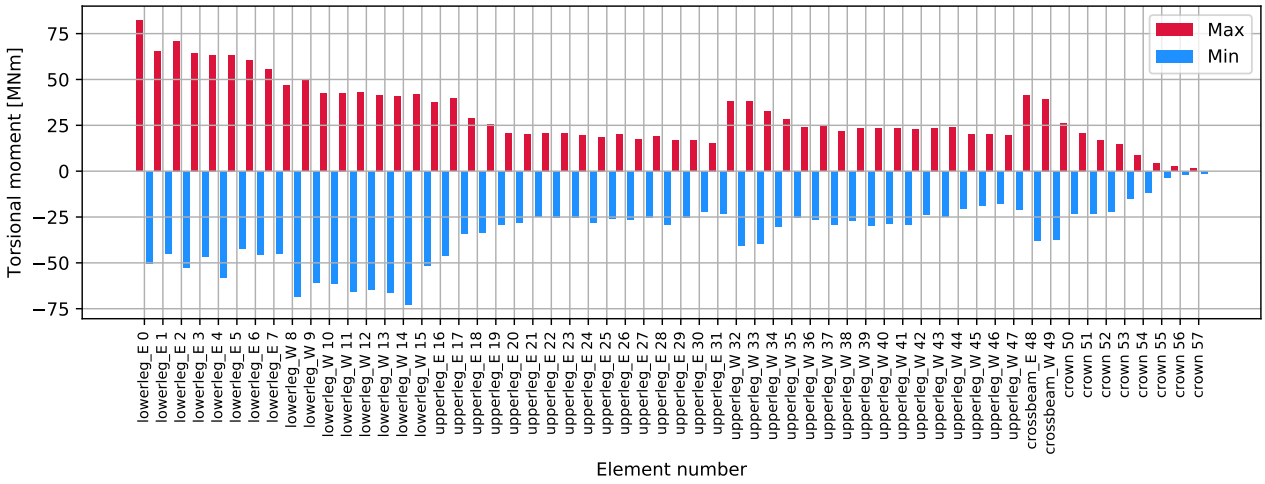

Figure 3.122: P A5 0deg - tower: Torsional moment [MNm]

3.3.3 Time series

Note : Time series are filtered using a Saviotzky-Golay filter for increased readability of the time history plots. Hence, maximum values that occur due to a rapid vibration are not shown in the plots. For maximum values, refer to the tabulated data.
All elements are numbered from South to North, bottom to top

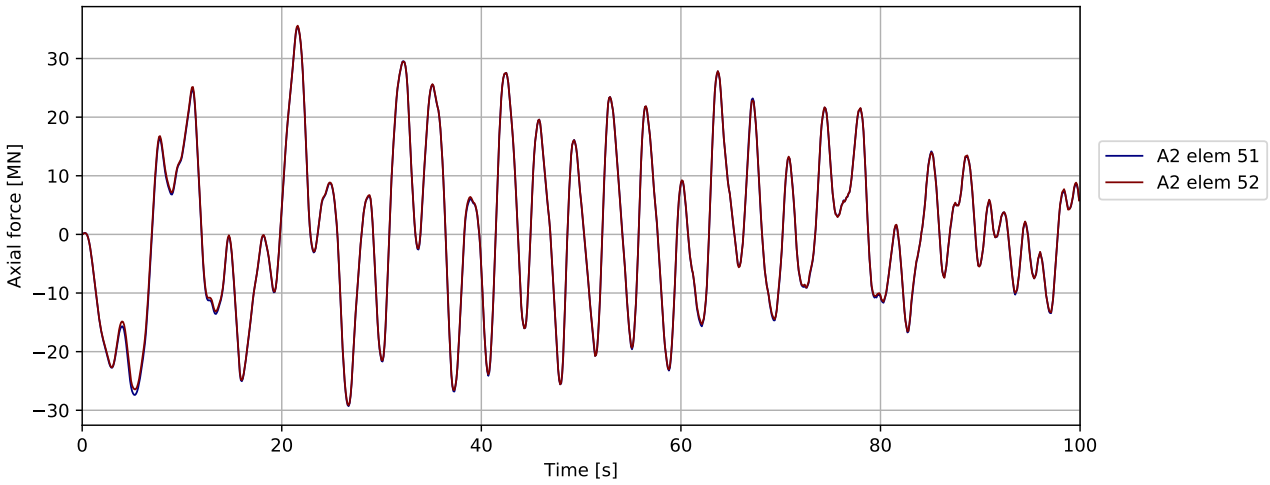

Figure 3.123: P A5 0deg - bridgegirder @ pylon: Axial force [MN]

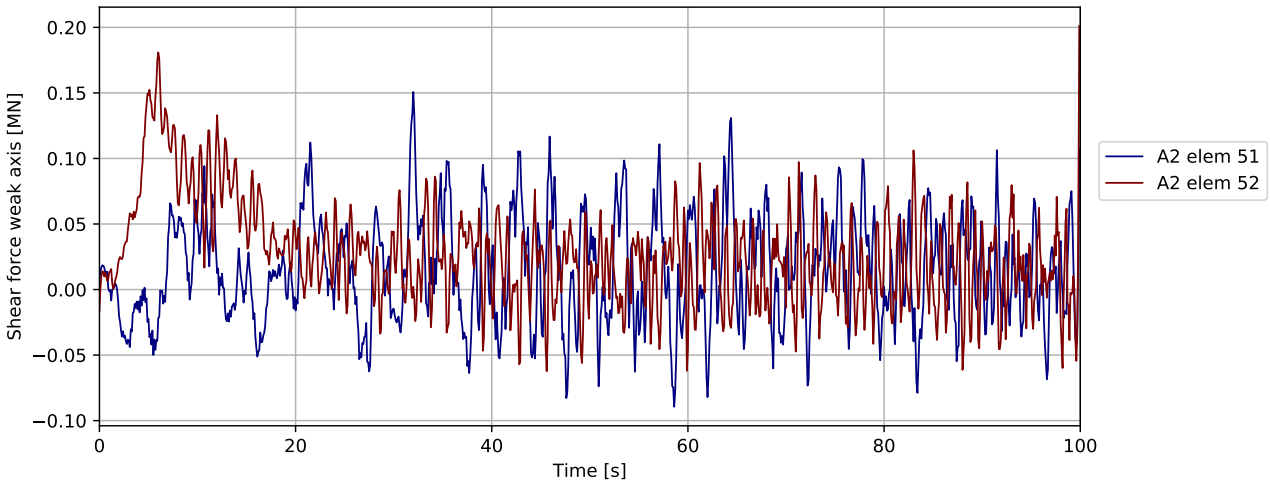

Figure 3.124: P A5 0deg - bridgegirder @ pylon: Shear force weak axis [MN]

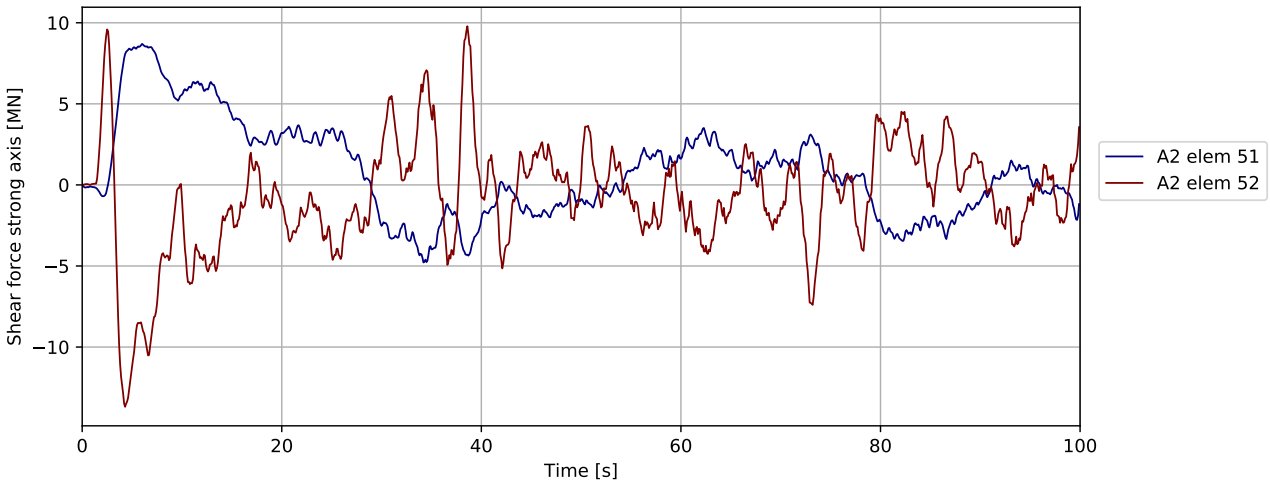

Figure 3.125: P A5 0deg - bridgegirder @ pylon: Shear force strong axis [MN]

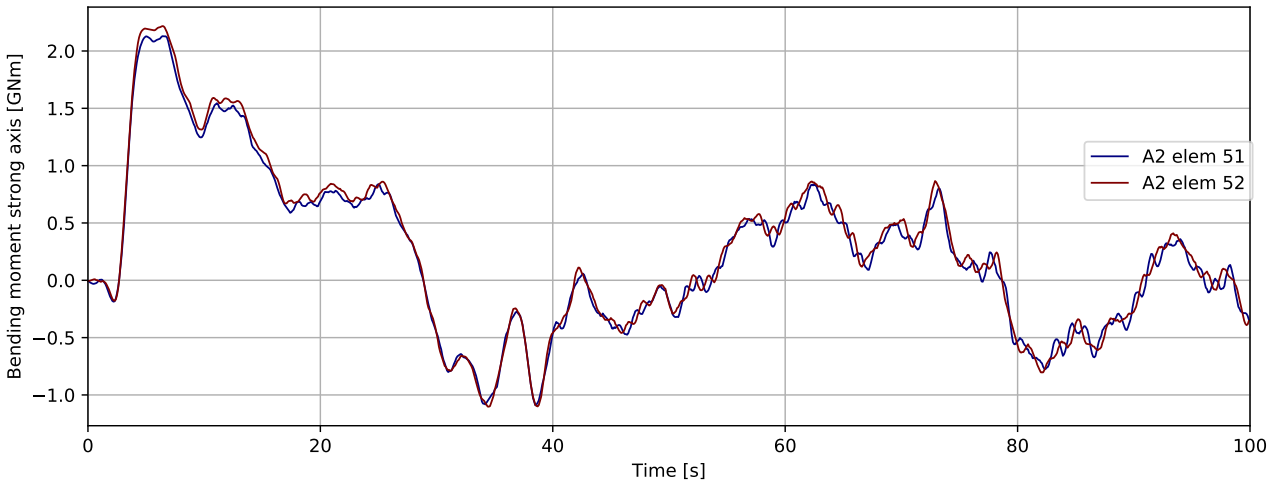

Figure 3.126: P A5 0deg - bridgegirder @ pylon: Bending moment strong axis [GNm]

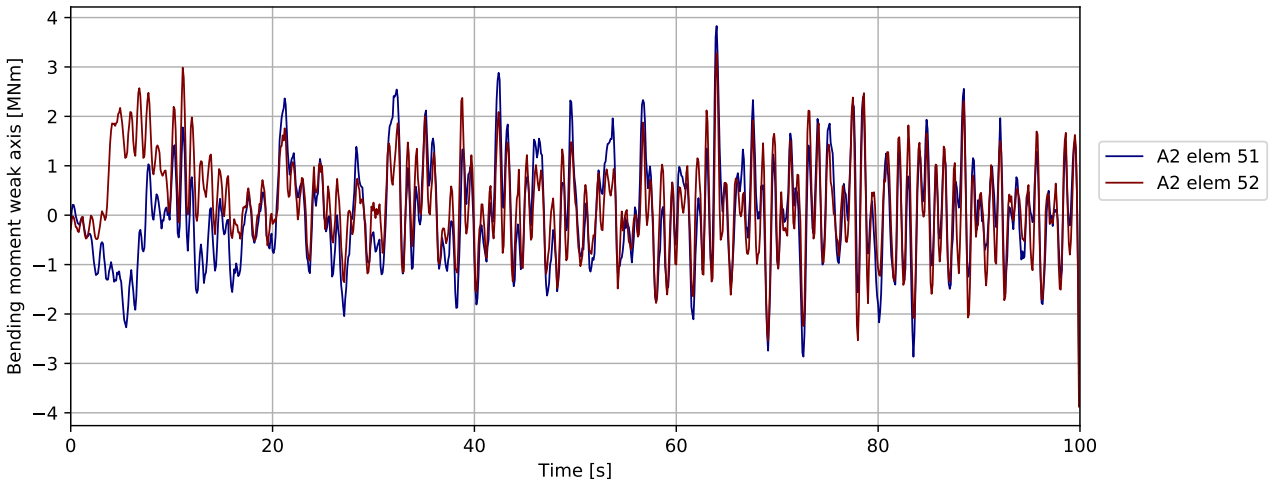

Figure 3.127: P A5 0deg - bridgegirder @ pylon: Bending moment weak axis [MNm]

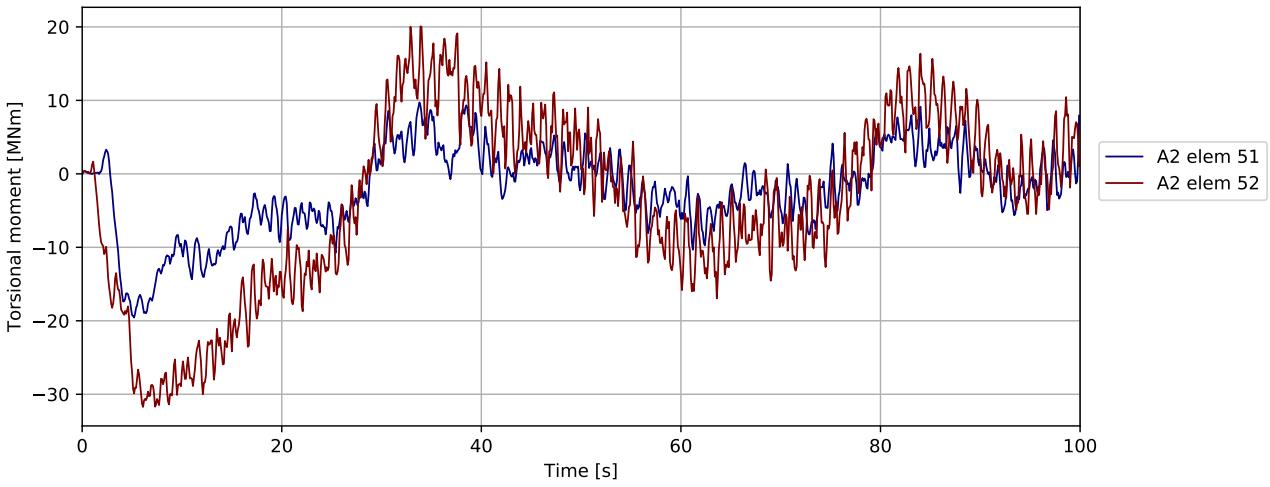

Figure 3.128: P A5 0deg - bridgegirder @ pylon: Torsional moment [MNm]

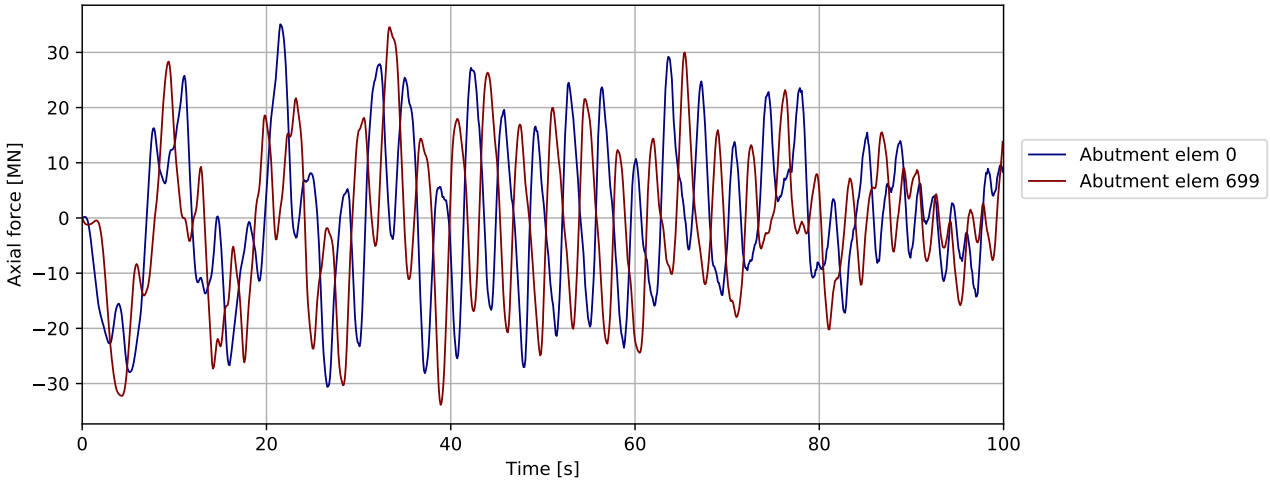

Figure 3.129: P A5 0deg - bridgegirder @abutments: Axial force [MN]

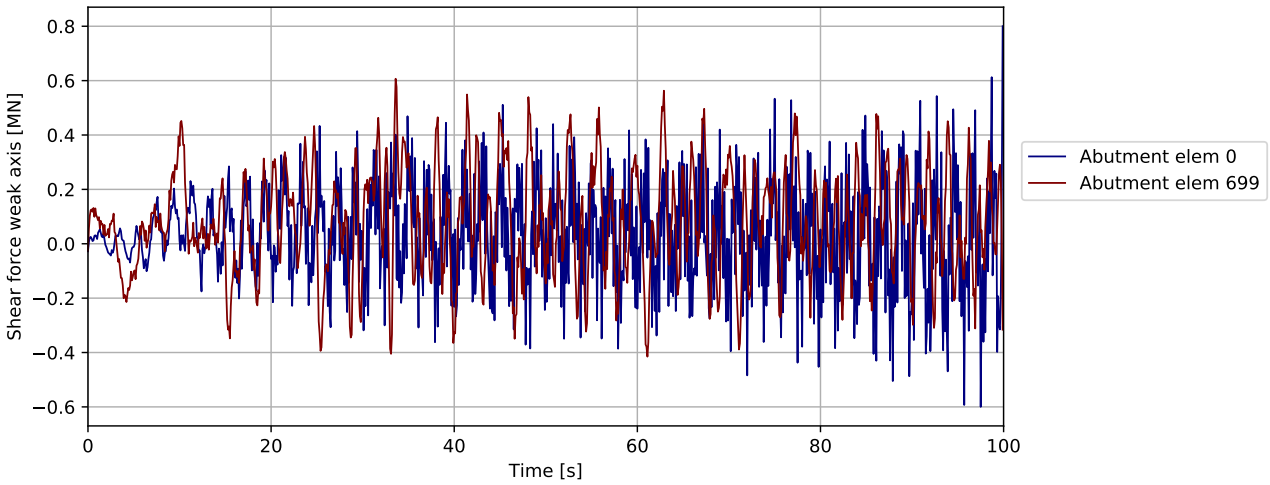

Figure 3.130: P A5 0deg - bridgegirder @abutments: Shear force weak axis [MN]

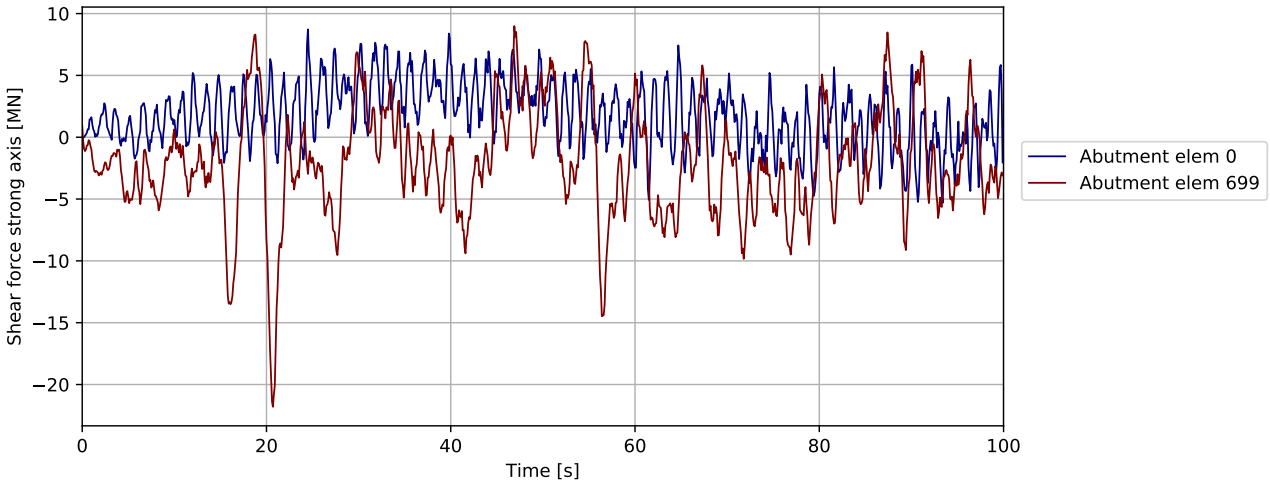

Figure 3.131: P A5 0deg - bridgegirder @abutments: Shear force strong axis [MN]

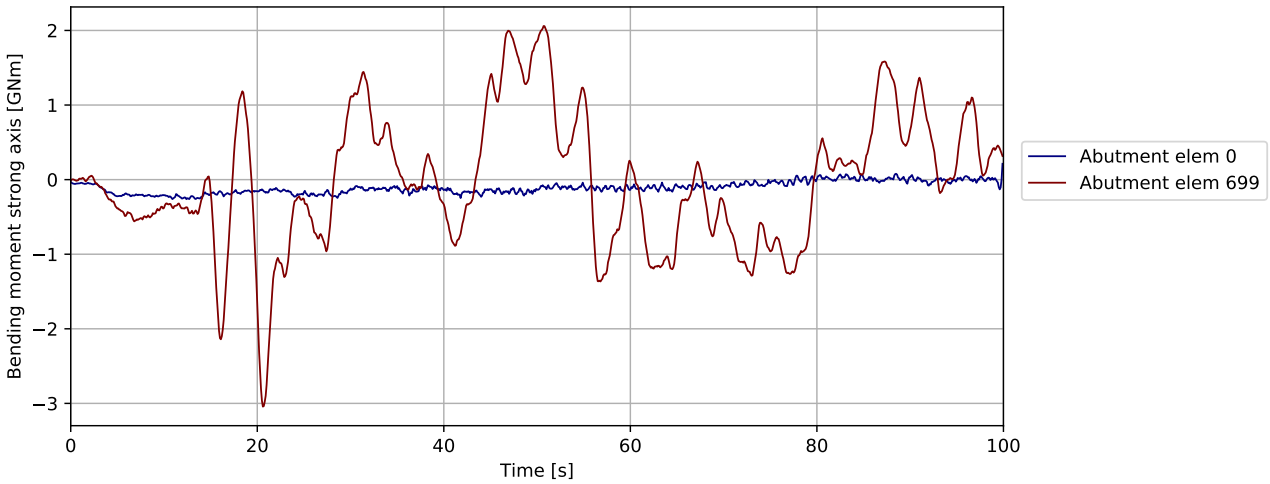

Figure 3.132: P A5 0deg - bridgegirder @abutments: Bending moment strong axis [GNm]

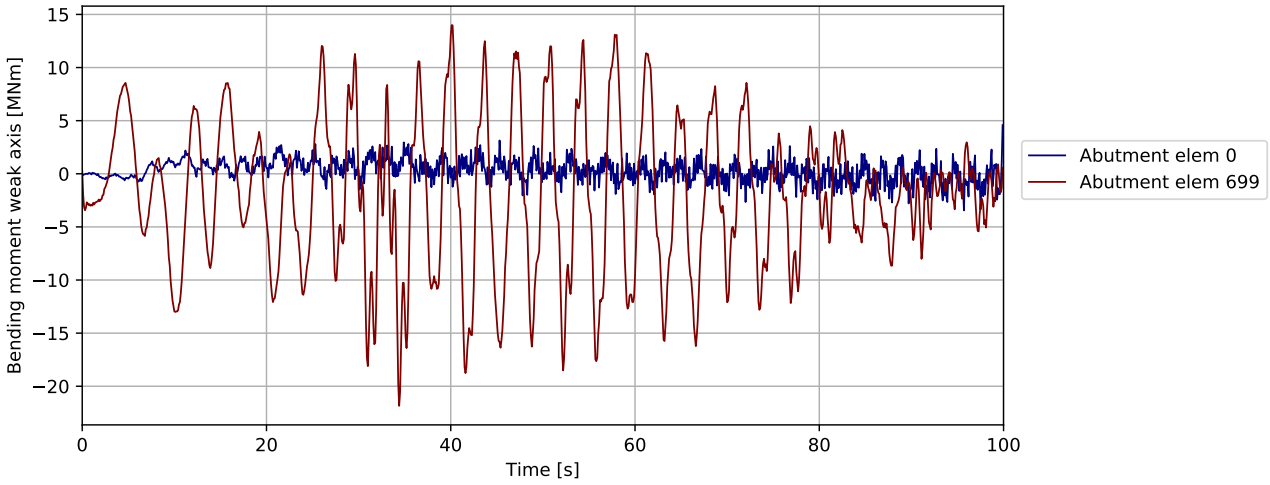

Figure 3.133: P A5 0deg - bridgegirder @abutments: Bending moment weak axis [MNm]

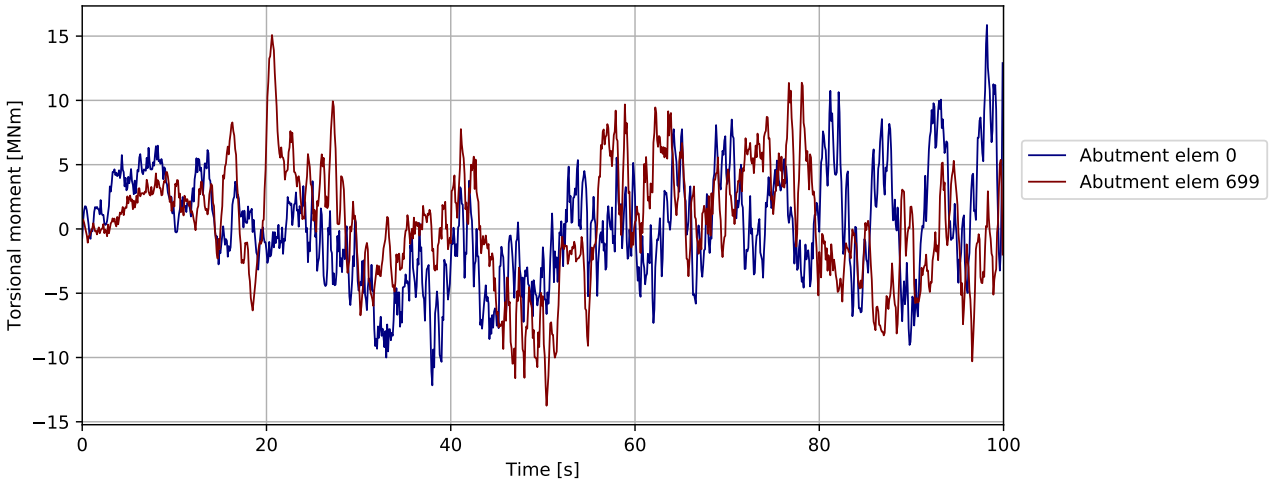

Figure 3.134: P A5 0deg - bridgegirder @abutments: Torsional moment [MNm]

Note : Compressive spring force is negative

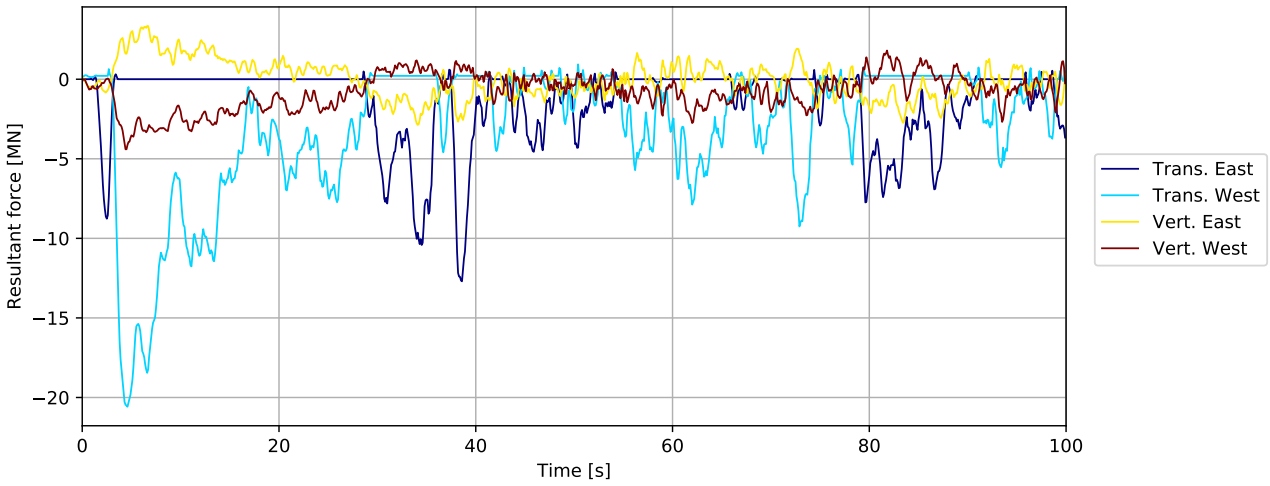

Figure 3.135: P A5 0deg - bridgegirder supports in tower: Resultant force [MN]

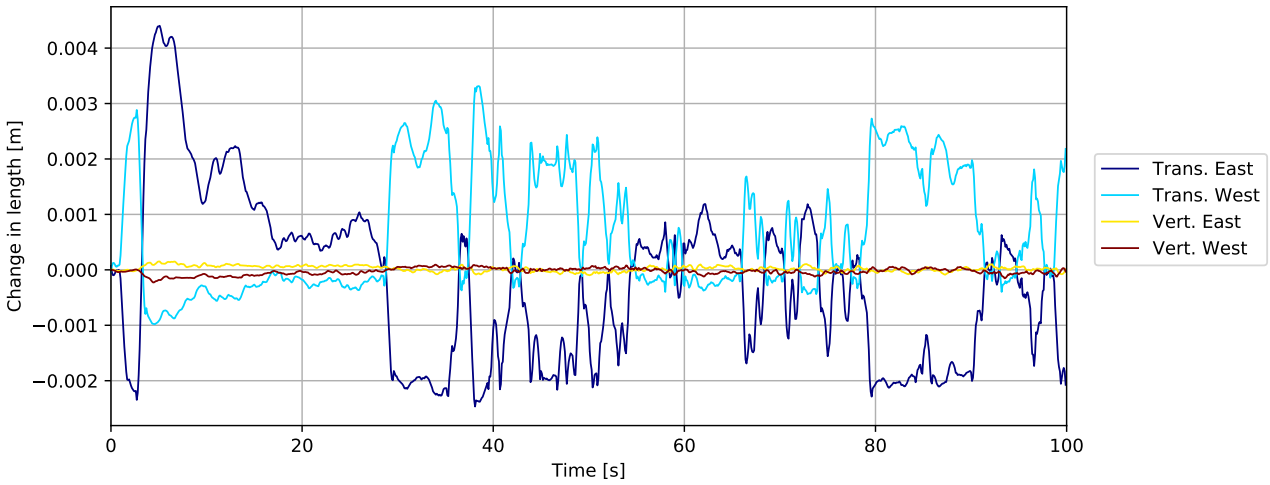

Figure 3.136: P A5 0deg - bridgegirder supports in tower: Change in length [m]

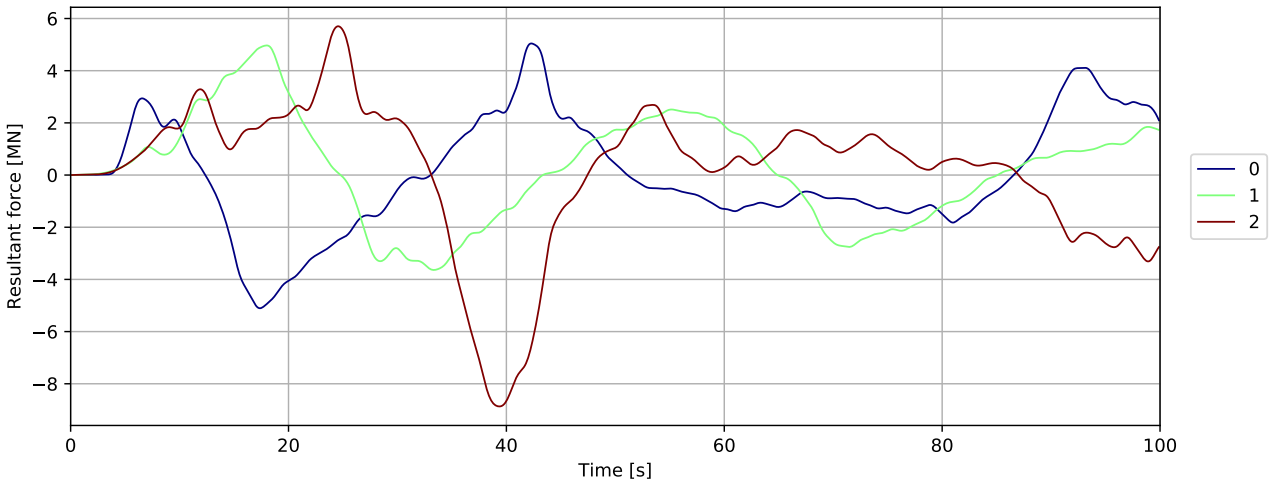

Figure 3.137: Mooring force

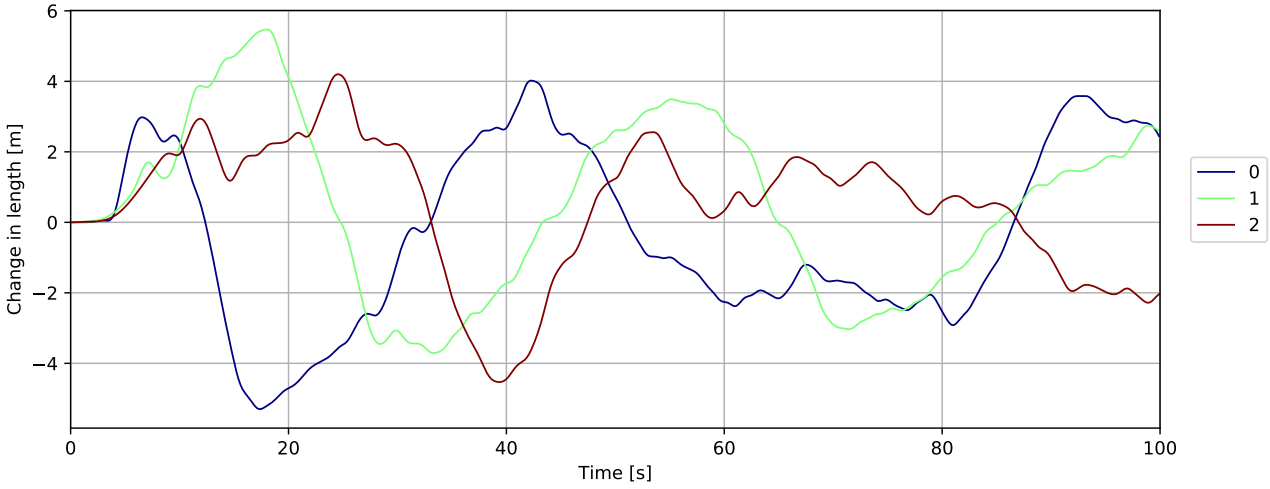

Figure 3.138: Mooring displacement

3.4 PontoonA10 0deg

3.4.1 Overall response

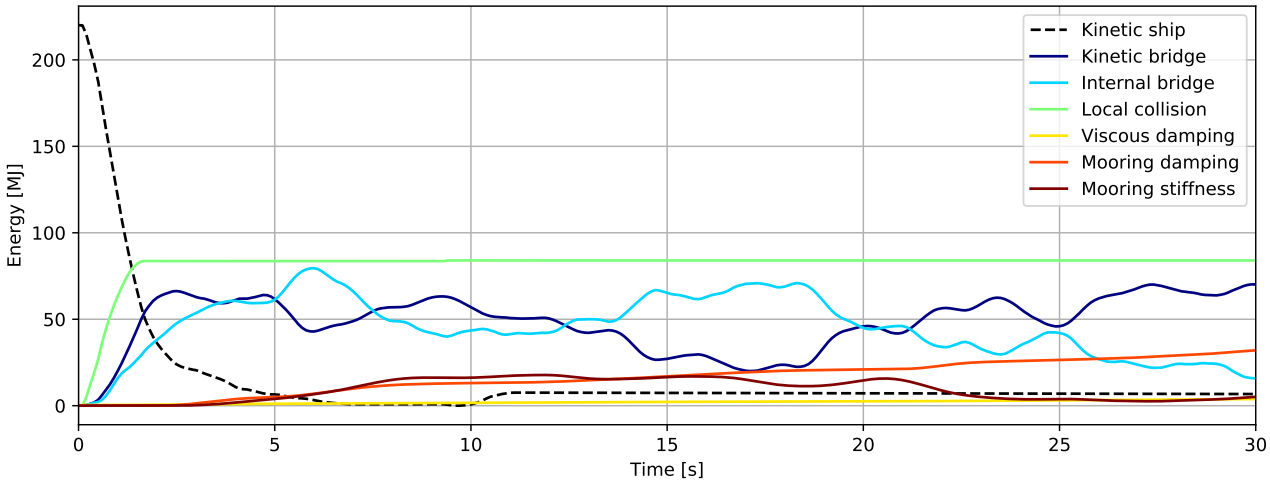

Figure 3.139: Energy [MJ] - initial phase

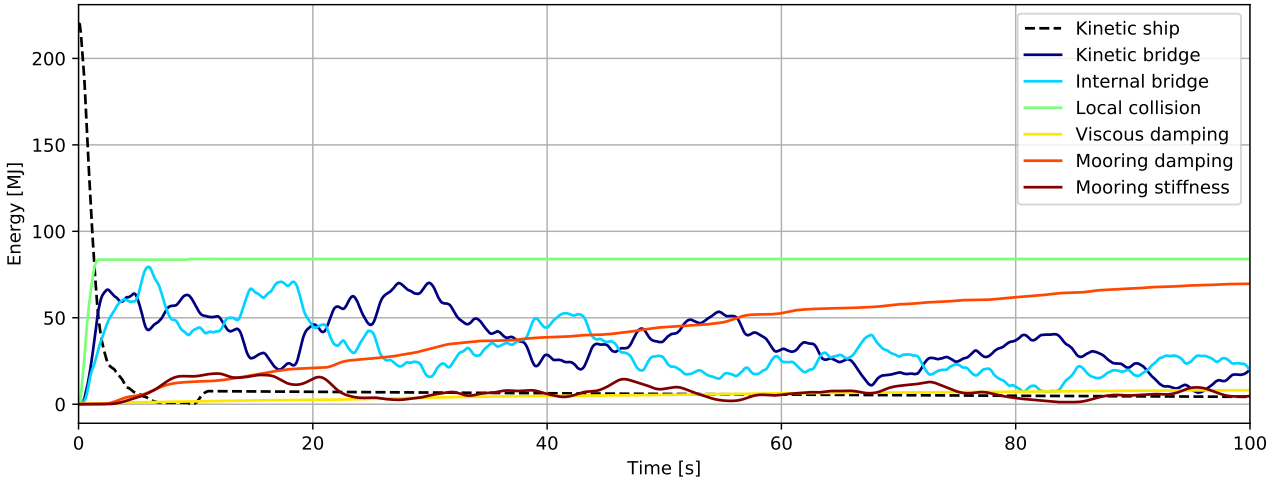

Figure 3.140: Energy [MJ]

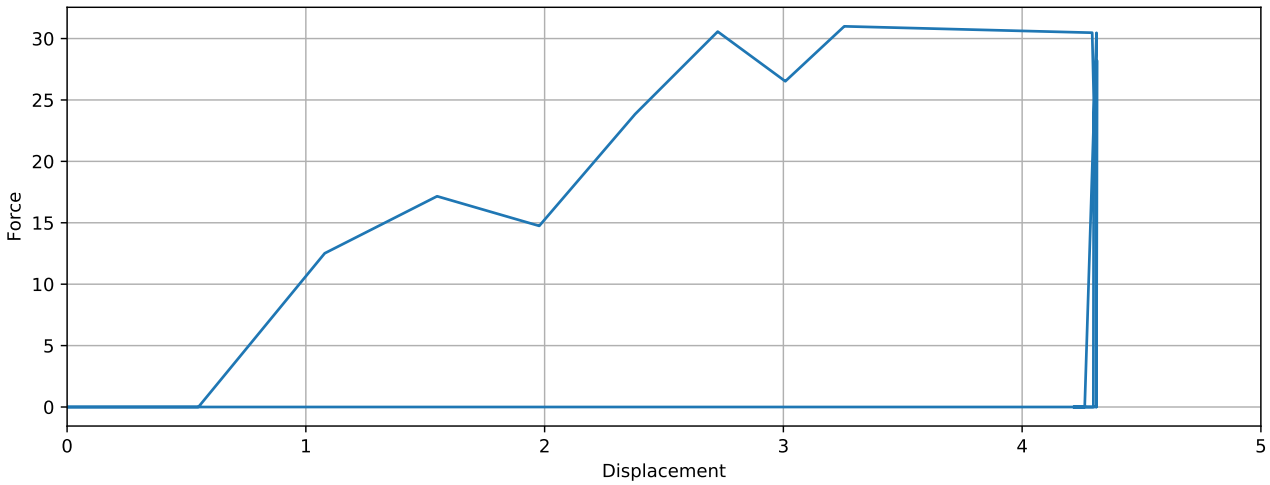

Figure 3.141: Simulated local collision force-displacement

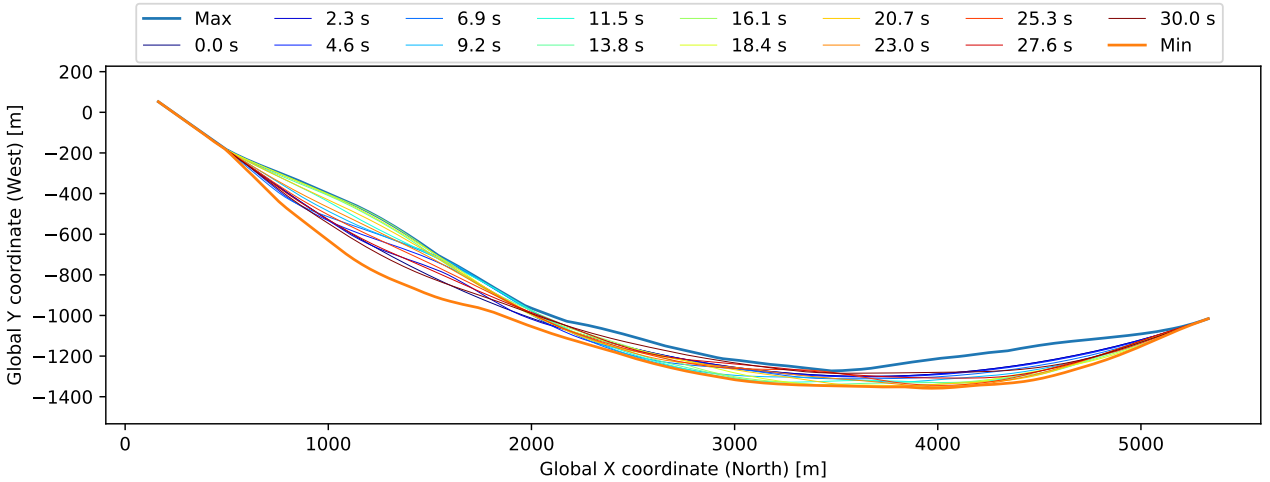

Figure 3.142: Bridgegirder deflection (10x displacment scaling)

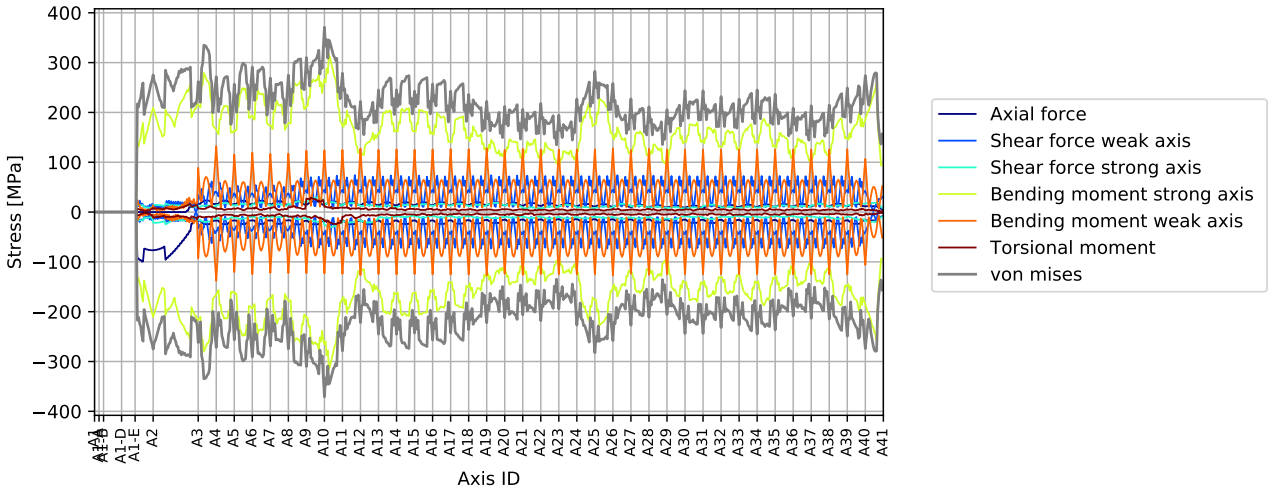

Figure 3.143: Stress envelope from all force components

3.4.2 Envelope plots

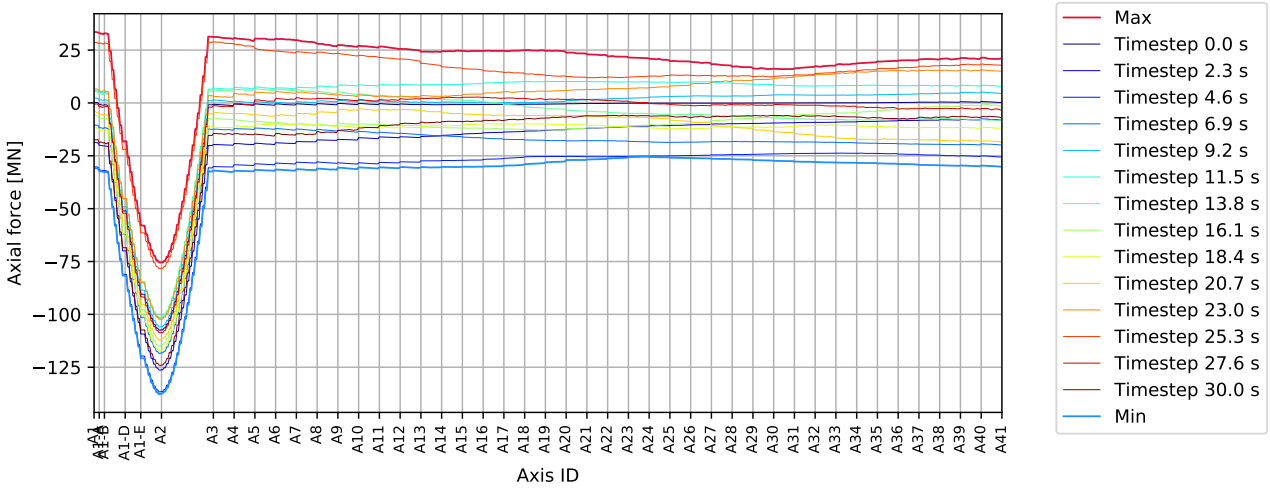

Figure 3.144: P A10 0deg - bridgegirder : Axial force [MN]

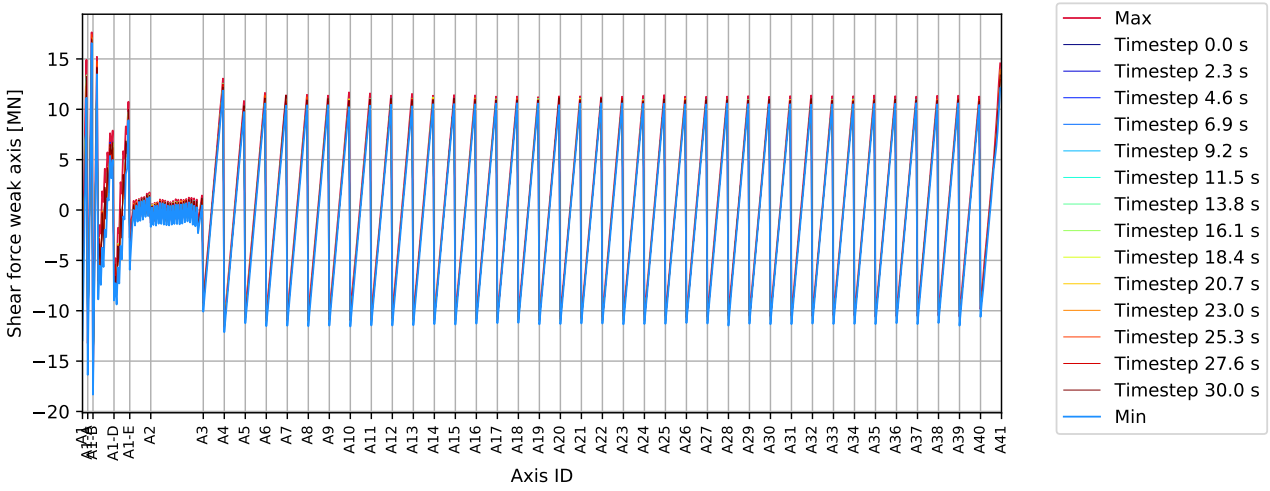

Figure 3.145: P A10 0deg - bridgegirder : Shear force weak axis [MN]

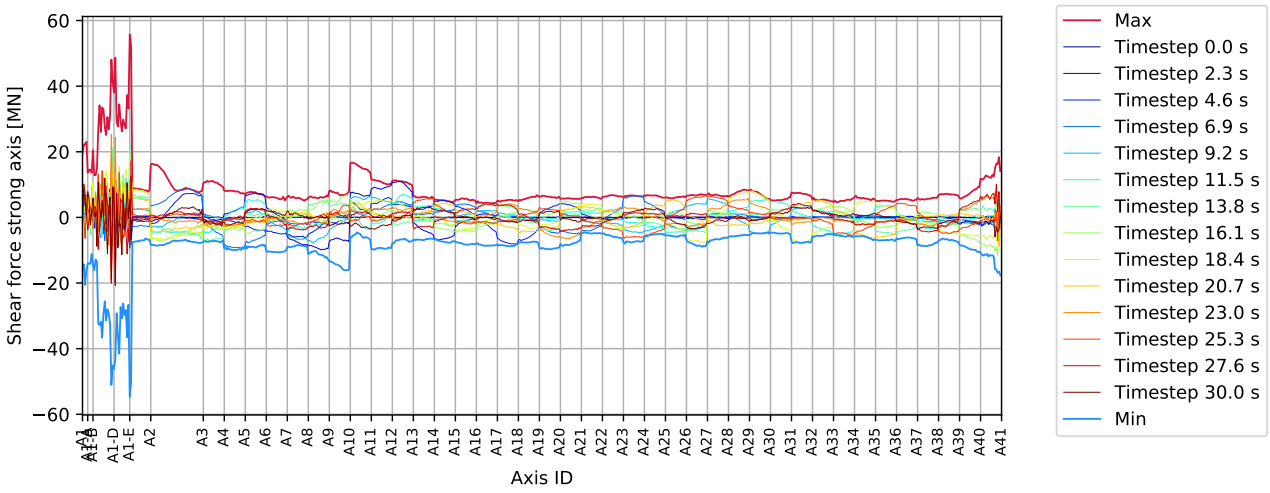

Figure 3.146: P A10 0deg - bridgegirder : Shear force strong axis [MN]

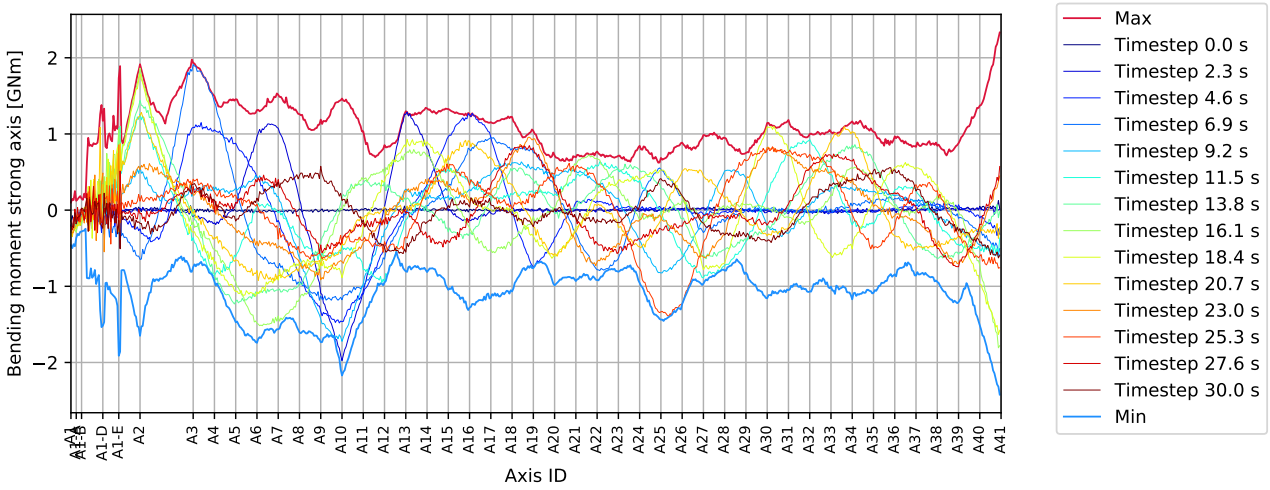

Figure 3.147: P A10 0deg - bridgegirder : Bending moment strong axis [GNm]

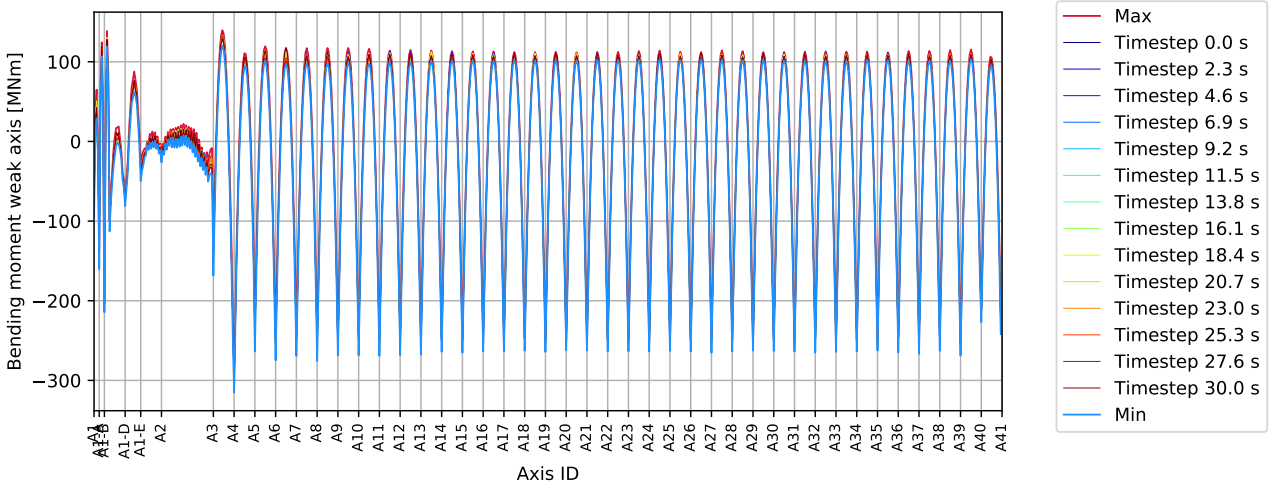

Figure 3.148: P A10 0deg - bridgegirder : Bending moment weak axis [MNm]

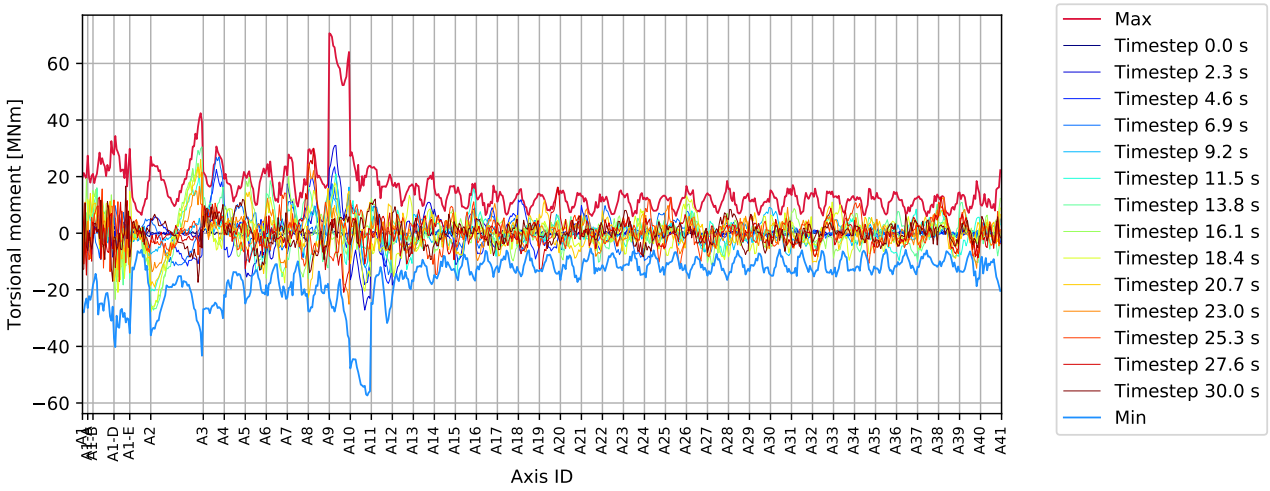

Figure 3.149: P A10 0deg - bridgegirder : Torsional moment [MNm]

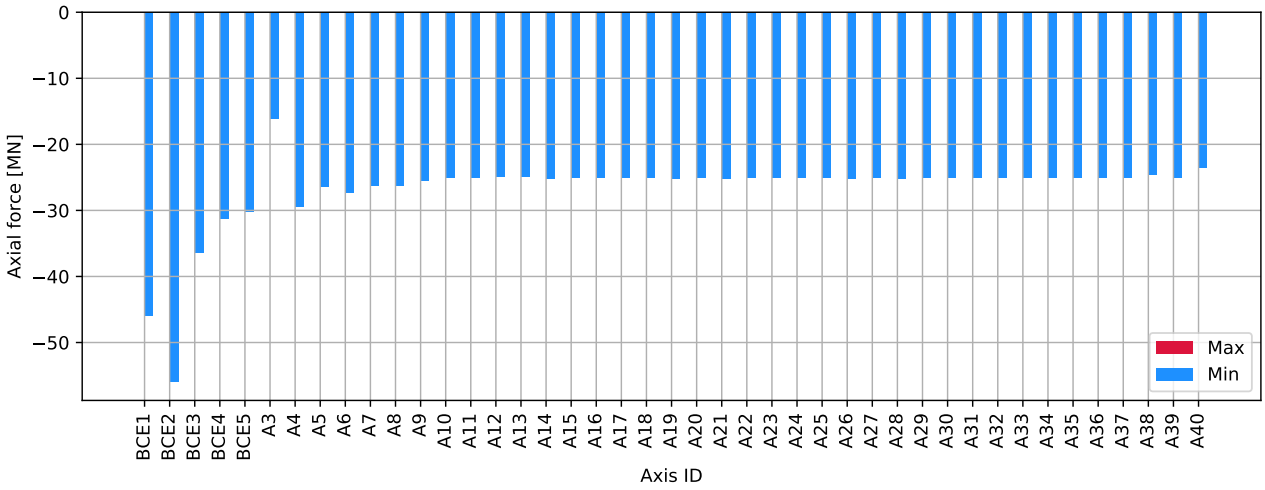

Figure 3.150: P A10 0deg - columns bottom : Axial force [MN]

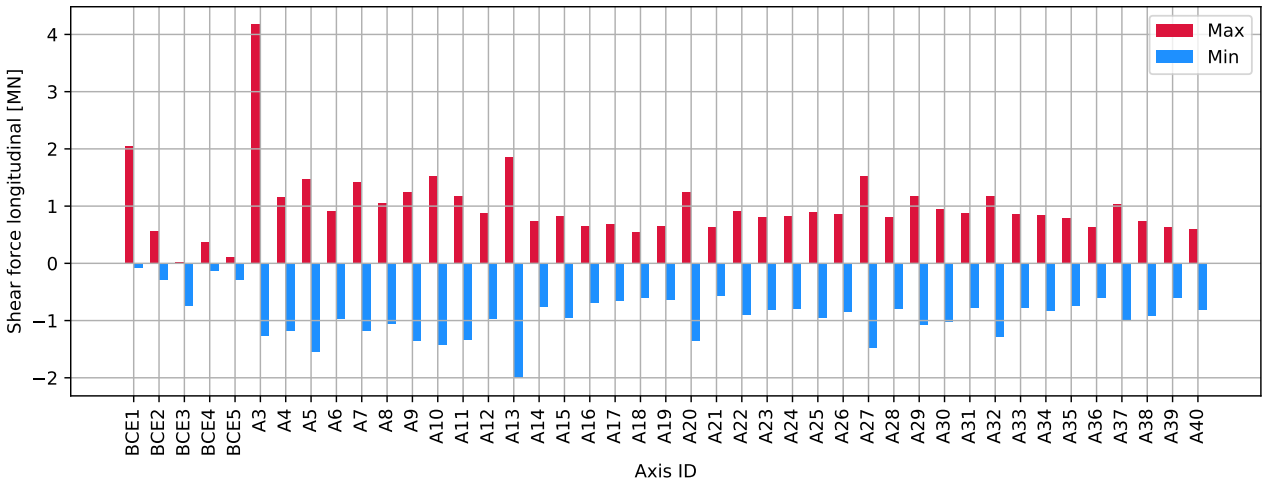

Figure 3.151: P A10 0deg - columns bottom : Shear force longitudinal [MN]

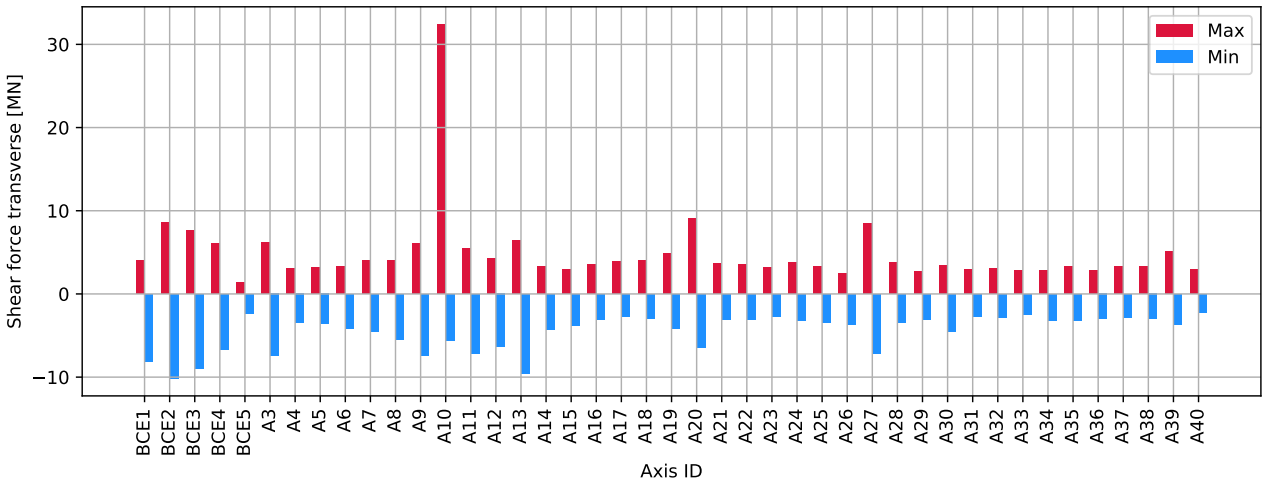

Figure 3.152: P A10 0deg - columns bottom : Shear force transverse [MN]

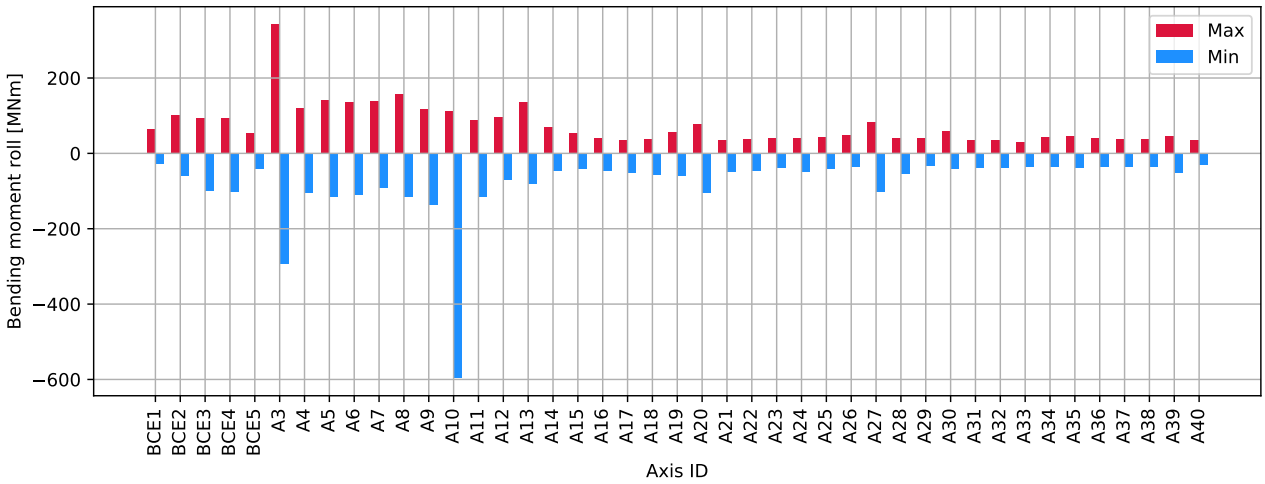

Figure 3.153: P A10 0deg - columns bottom : Bending moment roll [MNm]

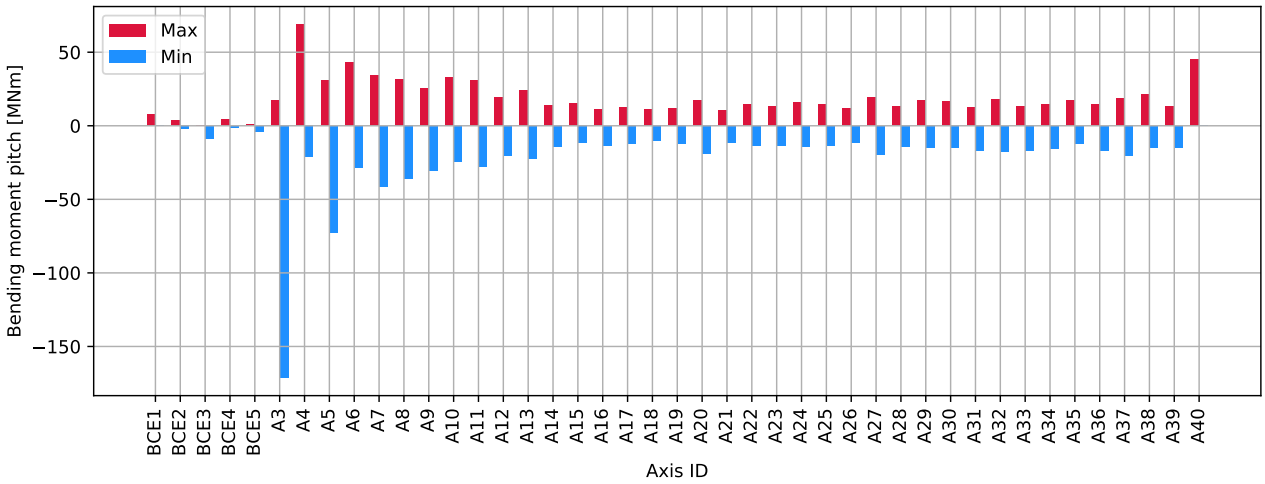

Figure 3.154: P A10 0deg - columns bottom : Bending moment pitch [MNm]

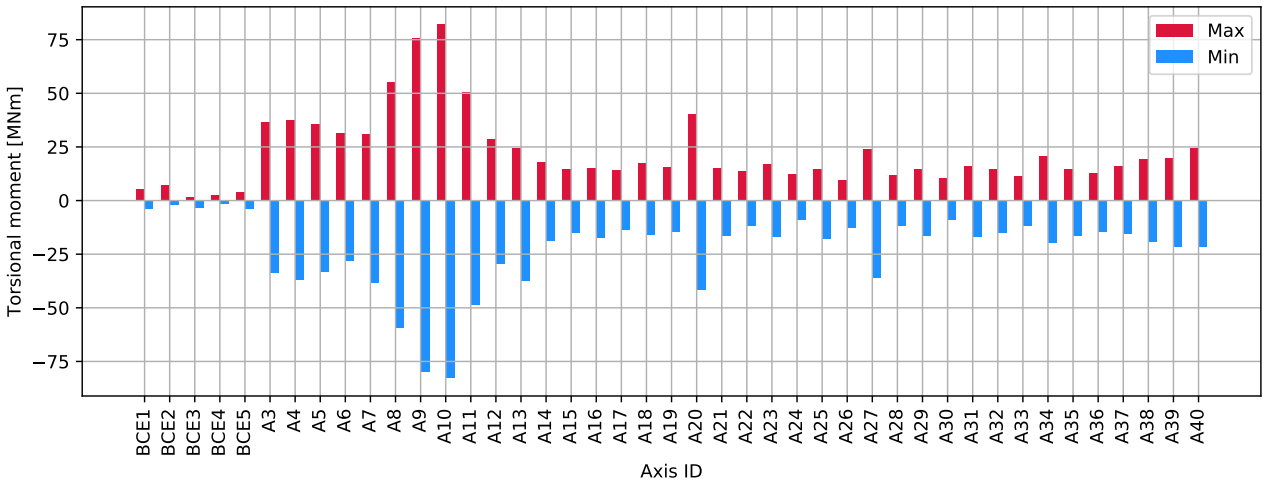

Figure 3.155: P A10 0deg - columns bottom : Torsional moment [MNm]

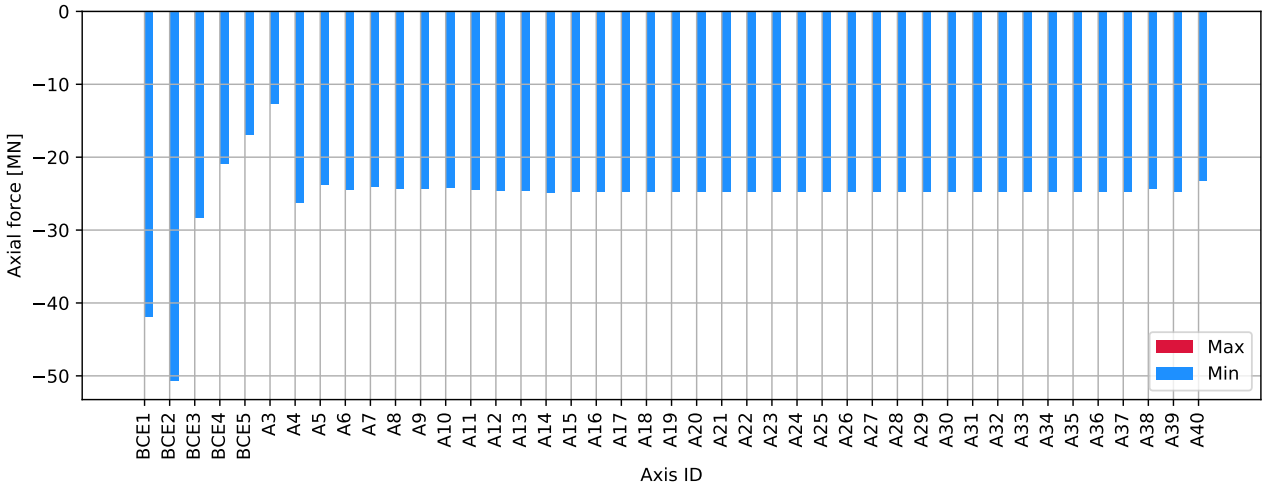

Figure 3.156: P A10 0deg - columns top : Axial force [MN]

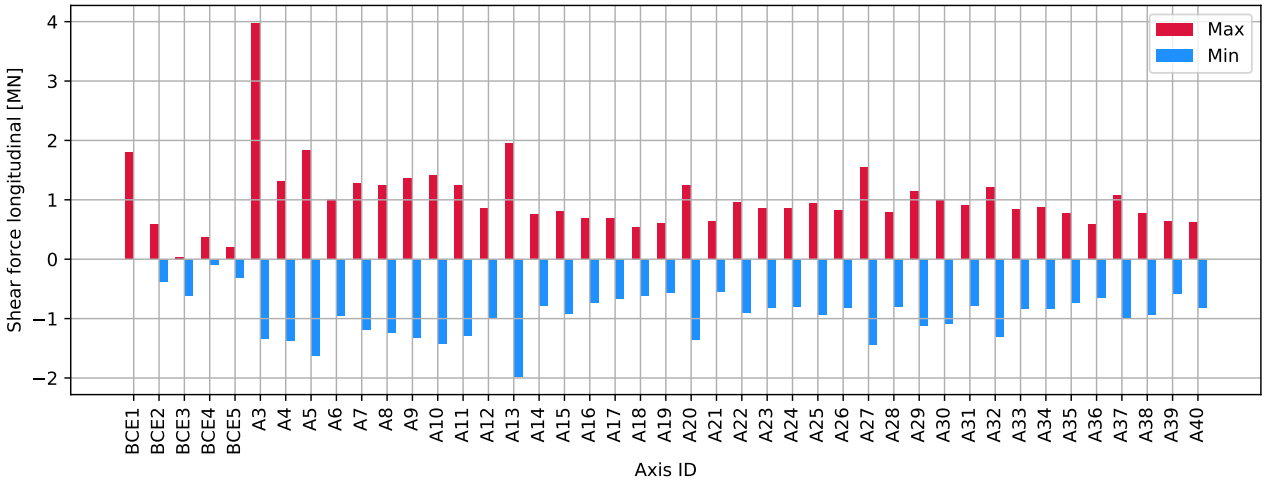

Figure 3.157: P A10 0deg - columns top : Shear force longitudinal [MN]

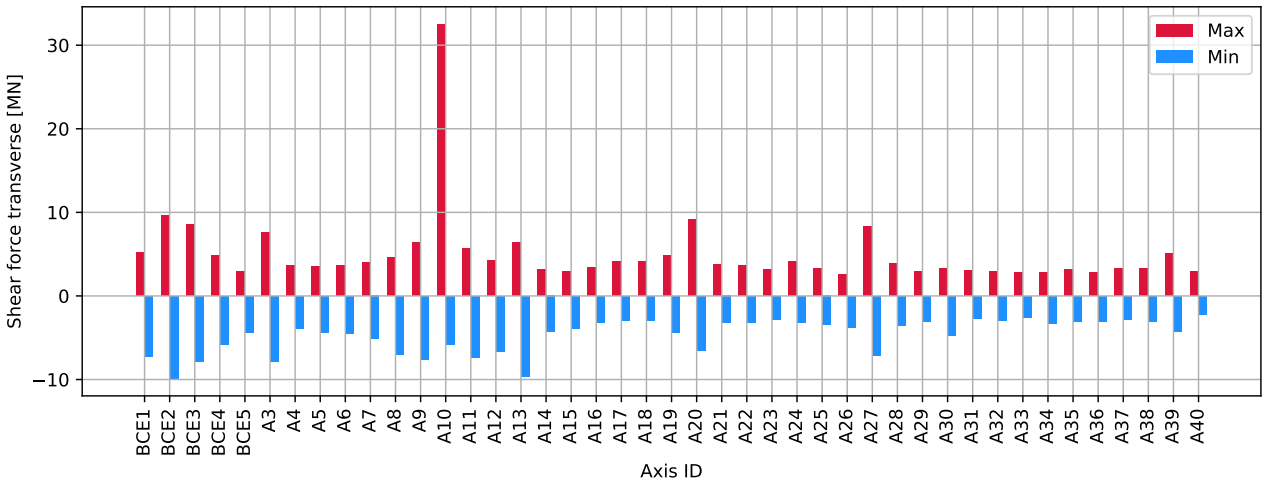

Figure 3.158: P A10 0deg - columns top : Shear force transverse [MN]

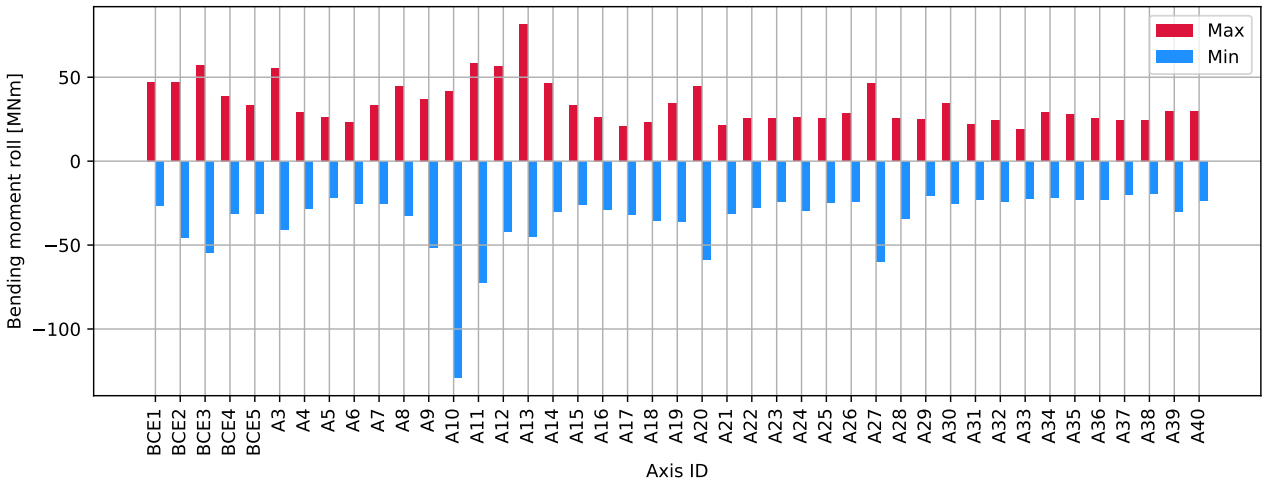

Figure 3.159: P A10 0deg - columns top : Bending moment roll [MNm]

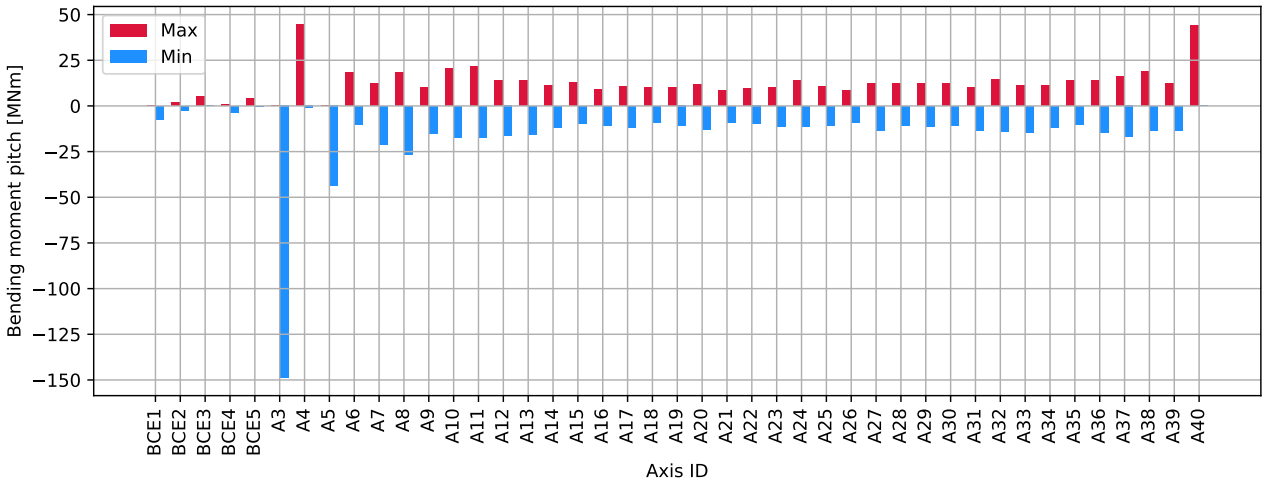

Figure 3.160: P A10 0deg - columns top : Bending moment pitch [MNm]

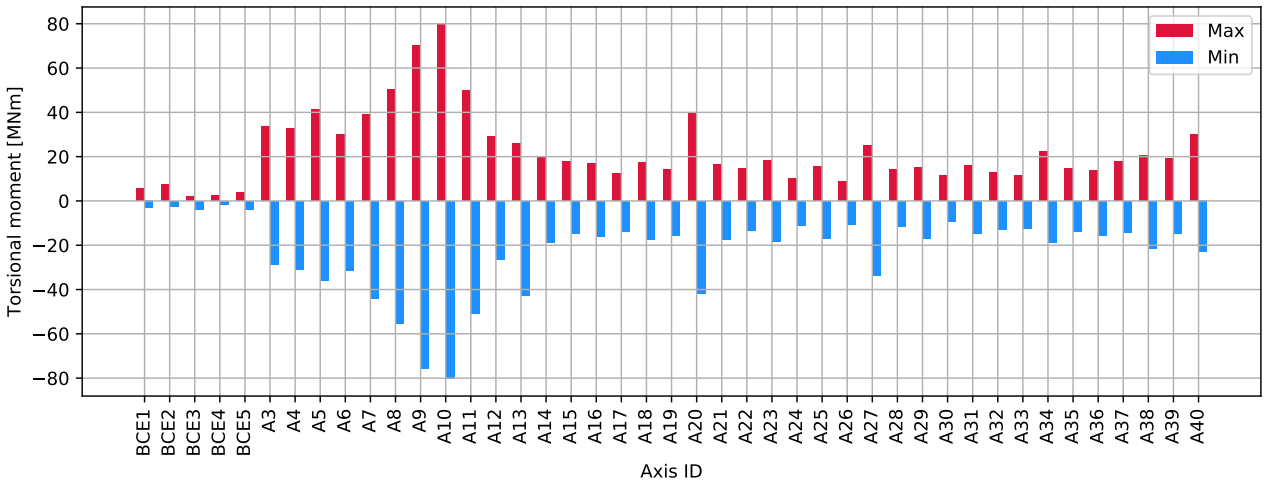

Figure 3.161: P A10 0deg - columns top : Torsional moment [MNm]

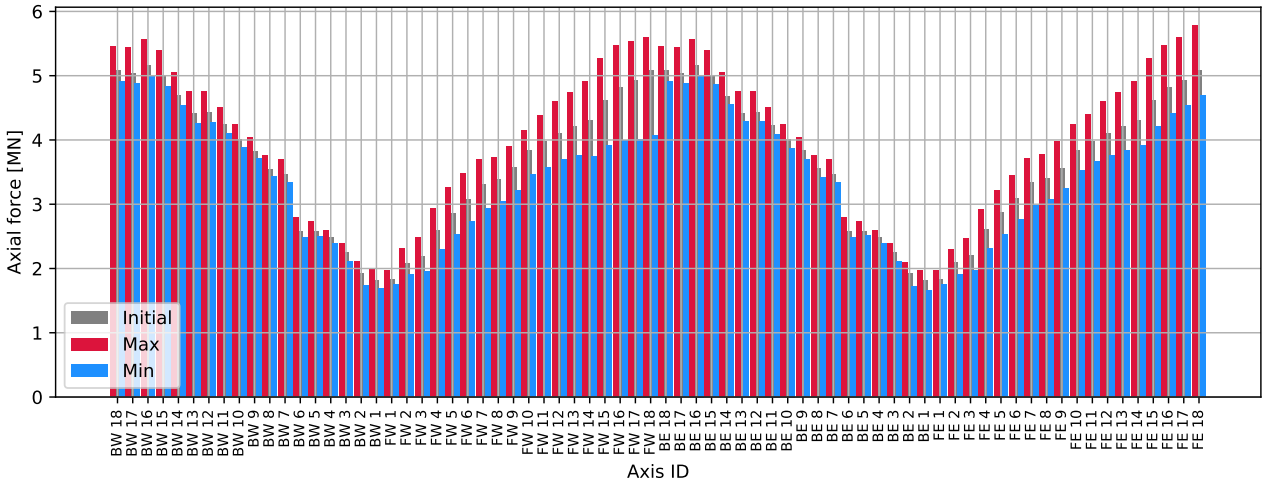

Figure 3.162: P A10 0deg - cables : Axial force [MN]

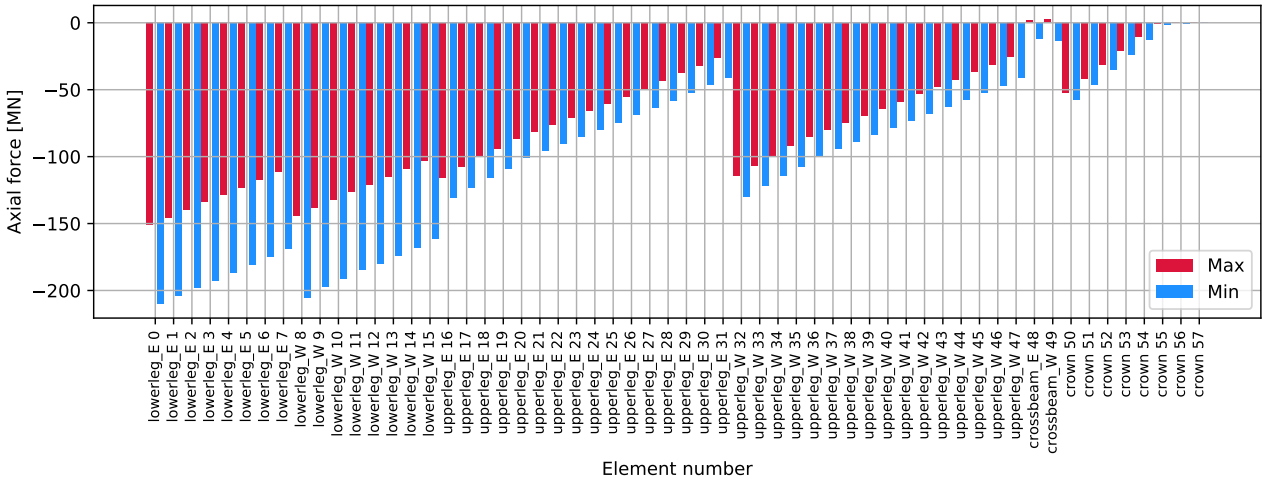

Figure 3.163: P A10 0deg - tower: Axial force [MN]

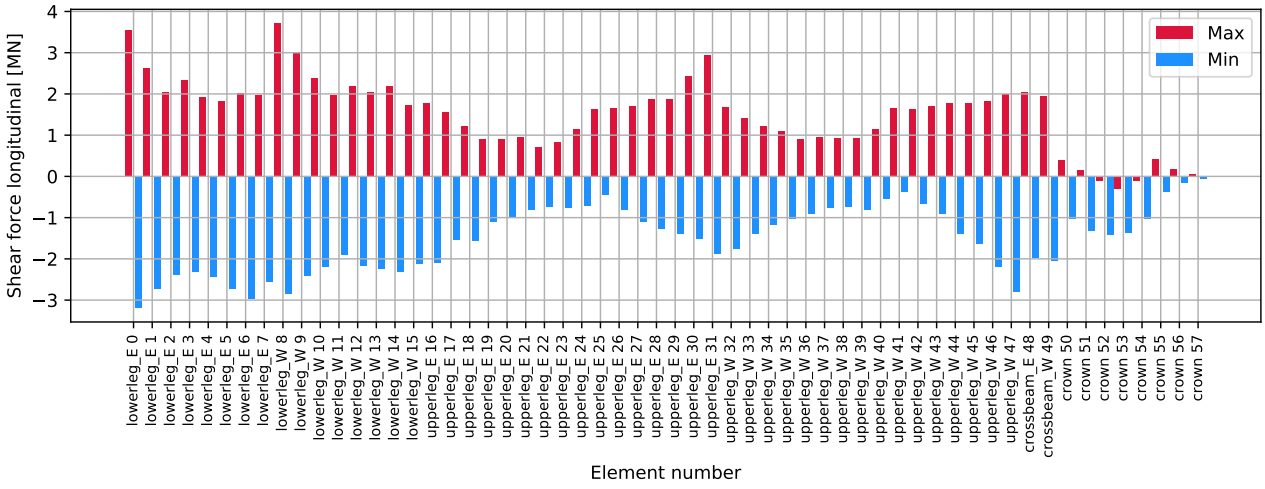

Figure 3.164: P A10 0deg - tower: Shear force longitudinal [MN]

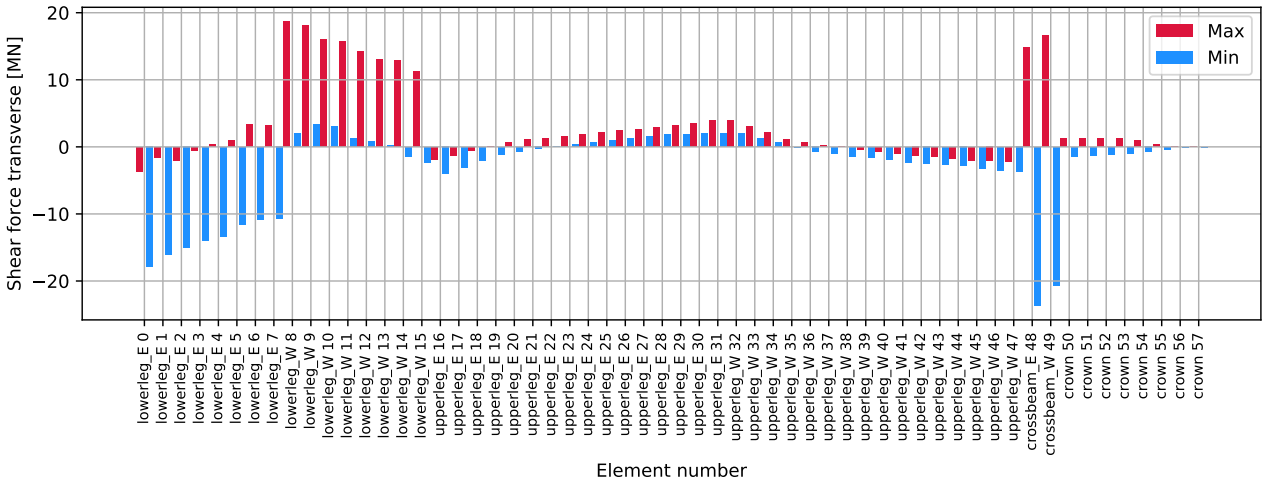

Figure 3.165: P A10 0deg - tower: Shear force transverse [MN]

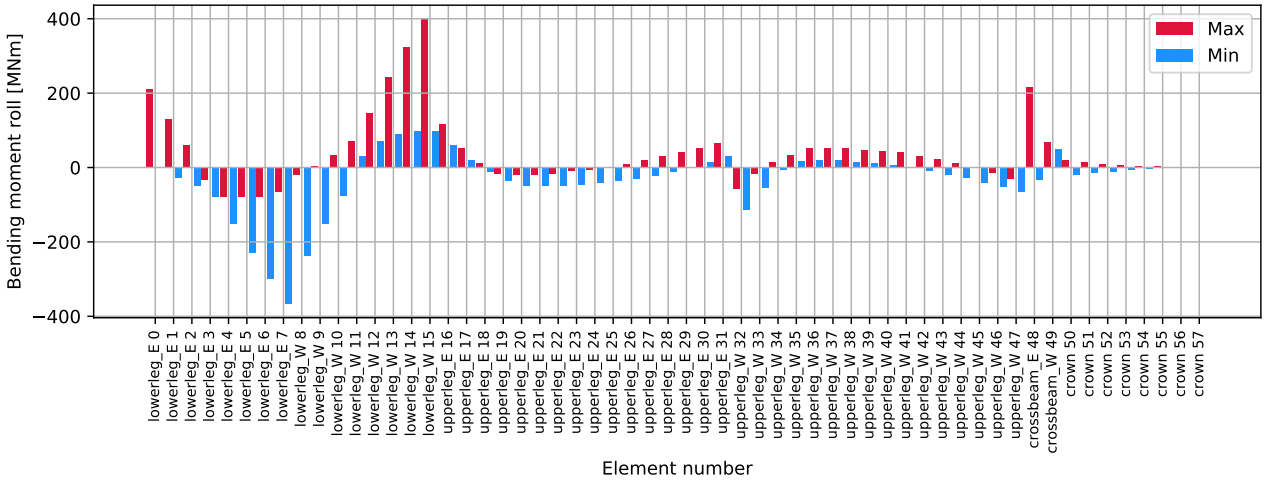

Figure 3.166: P A10 0deg - tower: Bending moment roll [MNm]

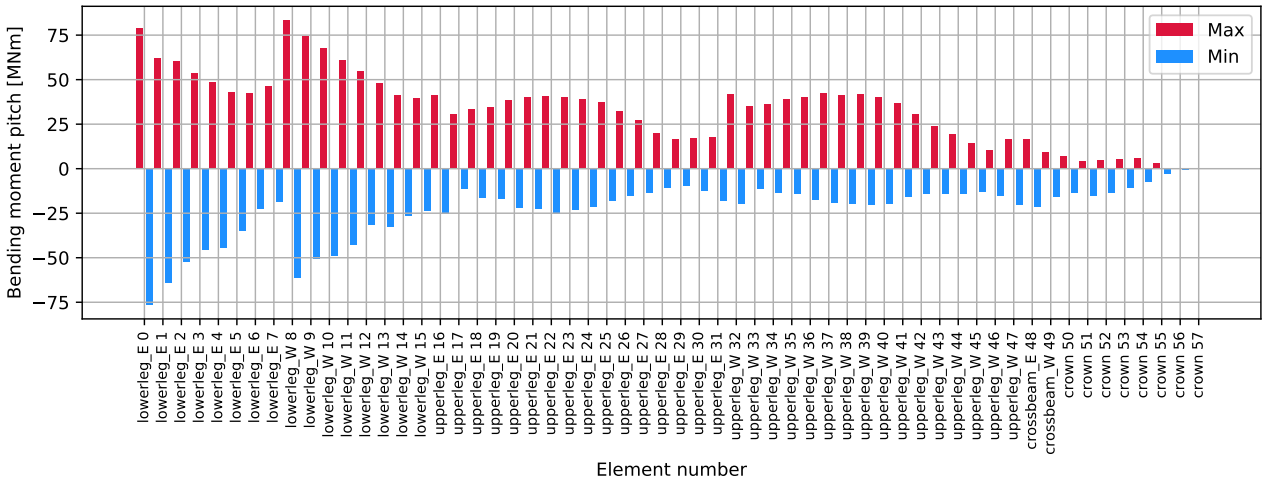

Figure 3.167: P A10 0deg - tower: Bending moment pitch [MNm]

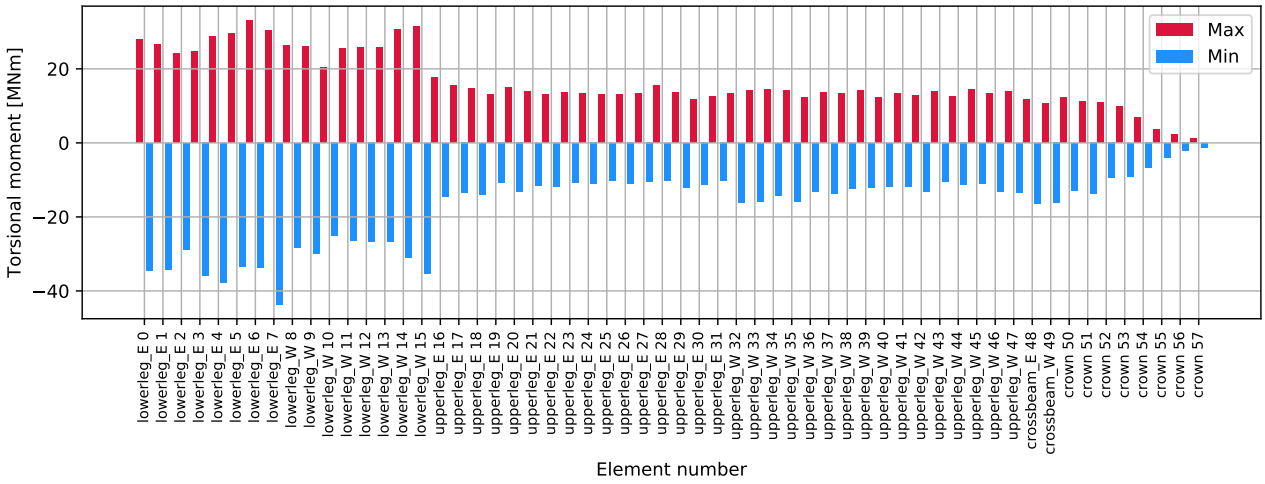

Figure 3.168: P A10 0deg - tower: Torsional moment [MNm]

3.4.3 Time series

Note : Time series are filtered using a Saviotzky-Golay filter for increased readability of the time history plots. Hence, maximum values that occur due to a rapid vibration are not shown in the plots. For maximum values, refer to the tabulated data.
All elements are numbered from South to North, bottom to top

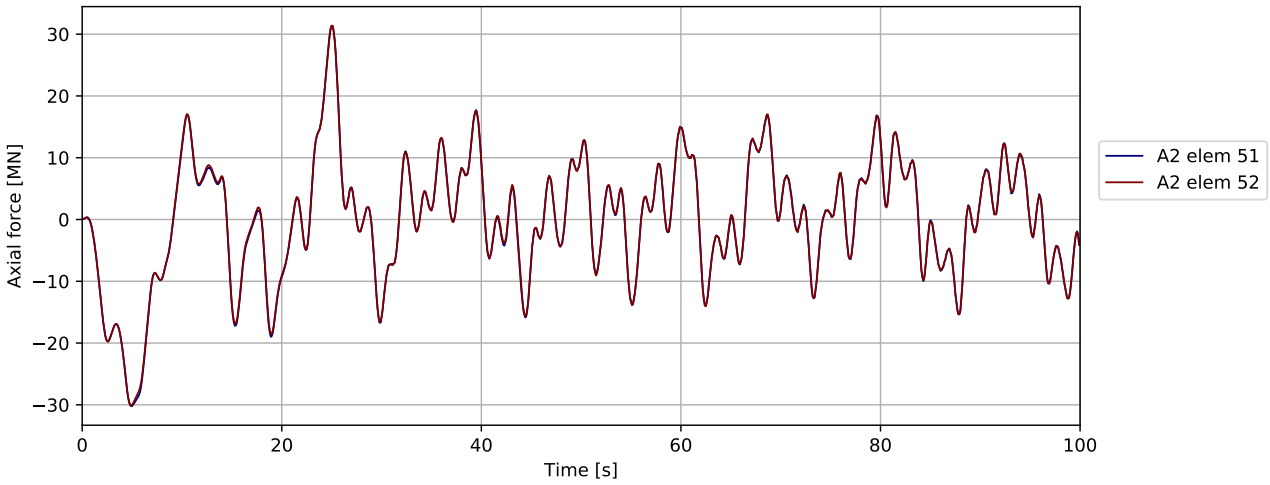

Figure 3.169: P A10 0deg - bridgegirder @ pylon: Axial force [MN]

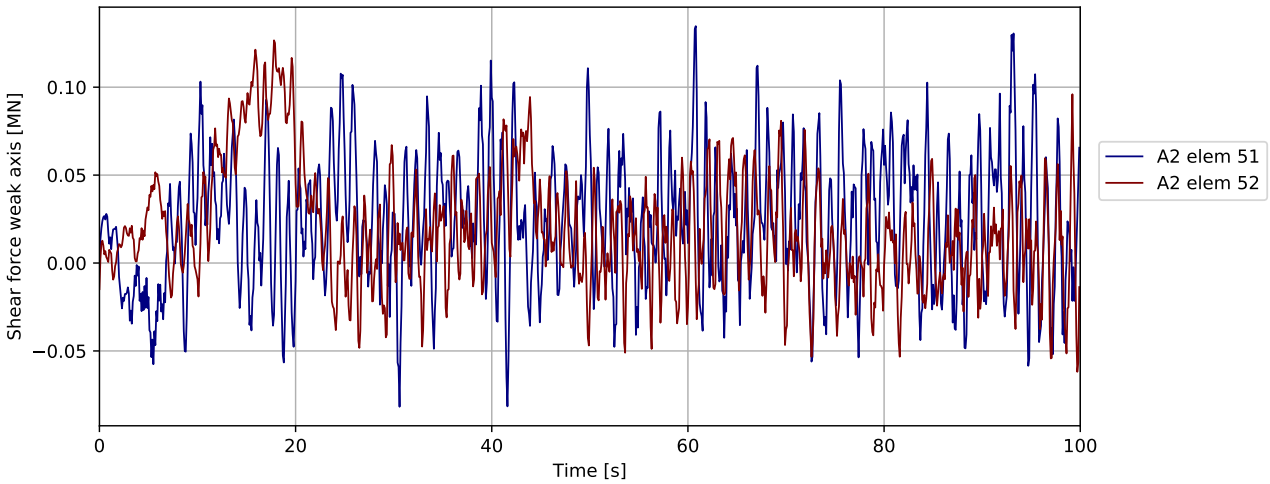

Figure 3.170: P A10 0deg - bridgegirder @ pylon: Shear force weak axis [MN]

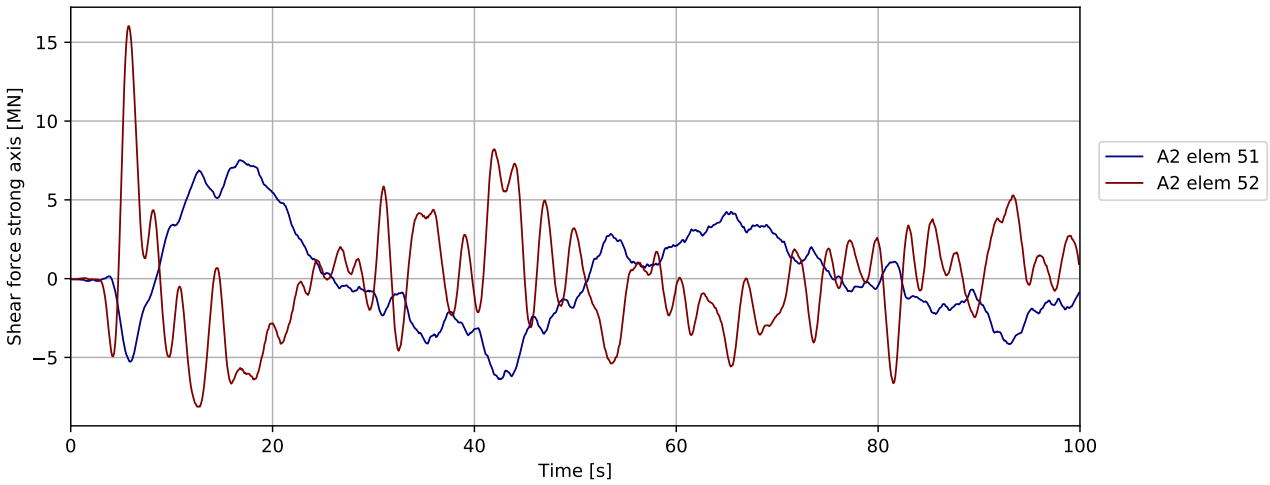

Figure 3.171: P A10 0deg - bridgegirder @ pylon: Shear force strong axis [MN]

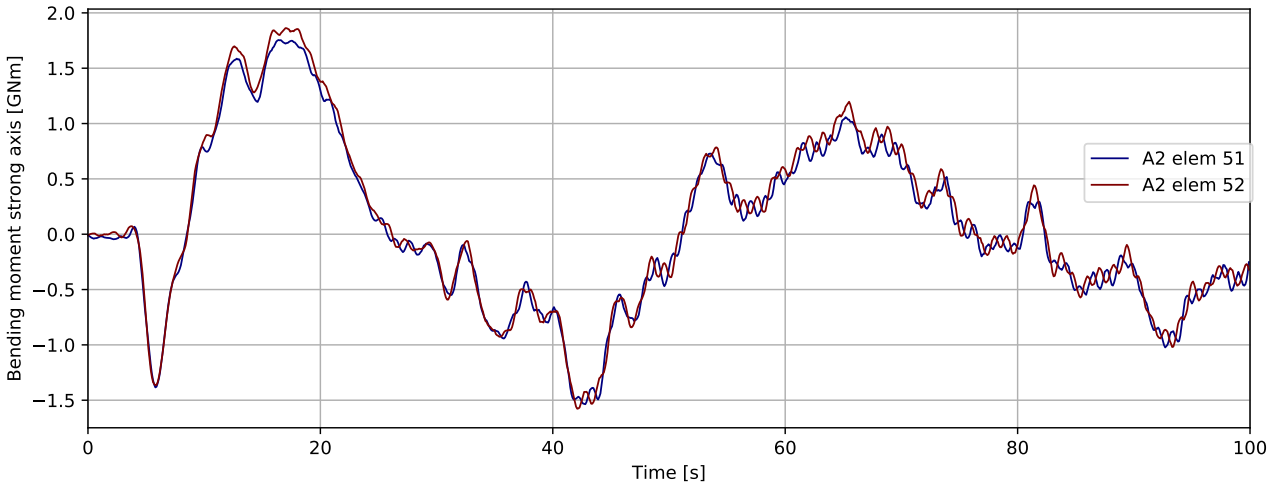

Figure 3.172: P A10 0deg - bridgegirder @ pylon: Bending moment strong axis [GNm]

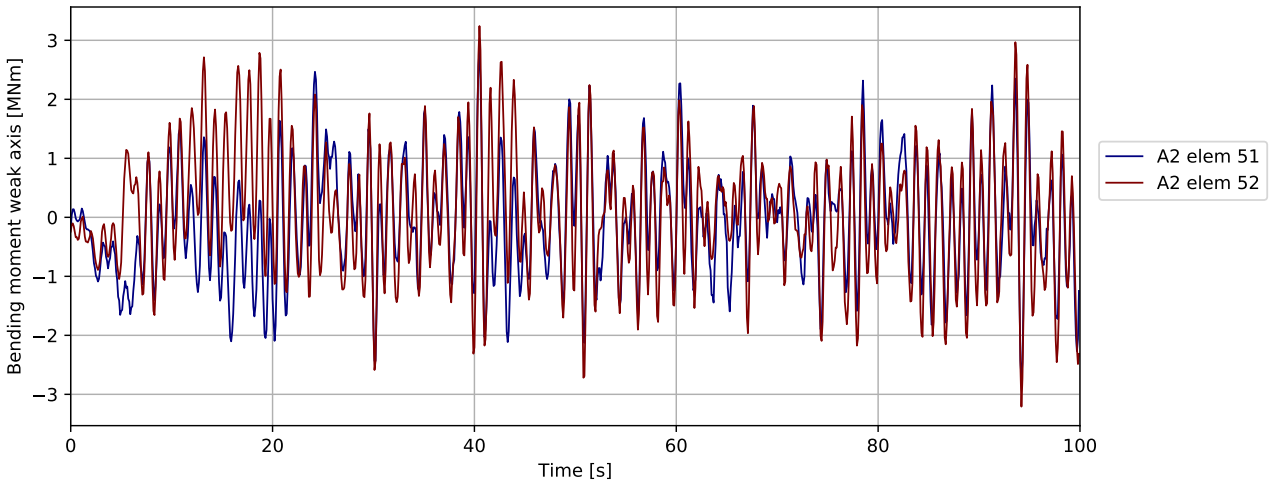

Figure 3.173: P A10 0deg - bridgegirder @ pylon: Bending moment weak axis [MNm]

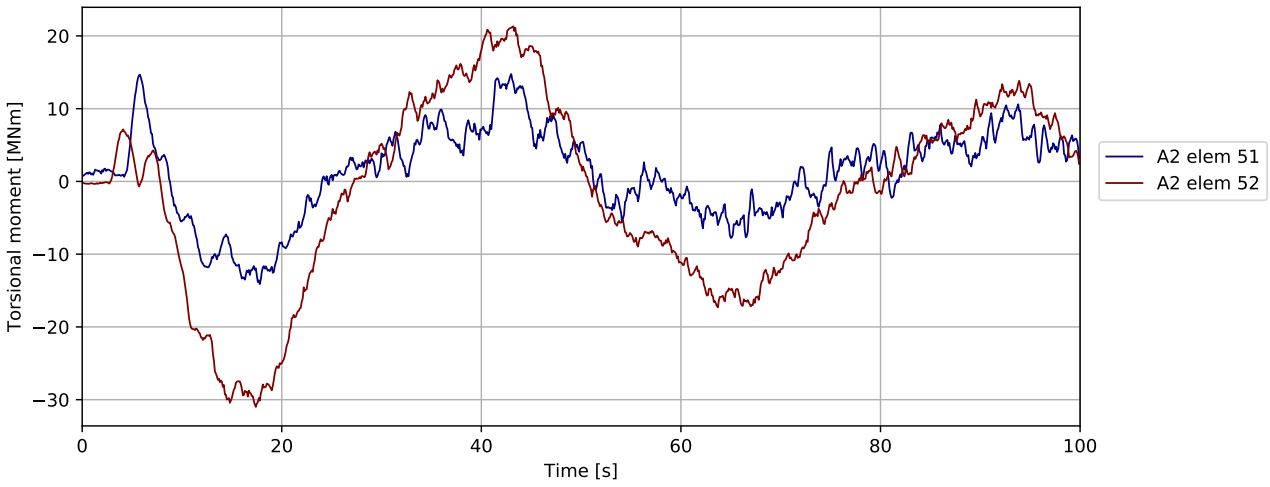

Figure 3.174: P A10 0deg - bridgegirder @ pylon: Torsional moment [MNm]

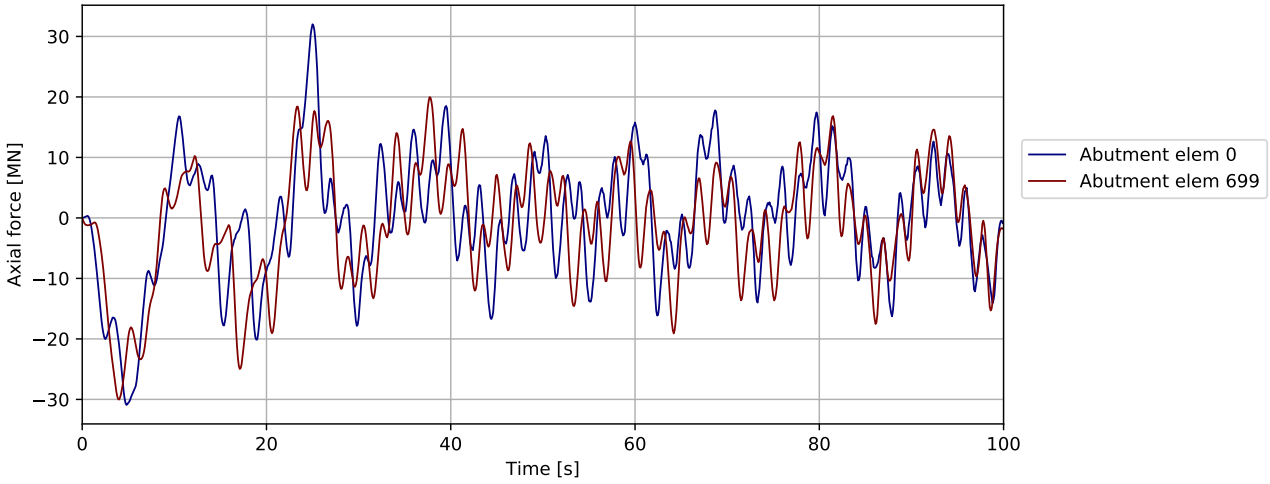

Figure 3.175: P A10 0deg - bridgegirder @abutments: Axial force [MN]

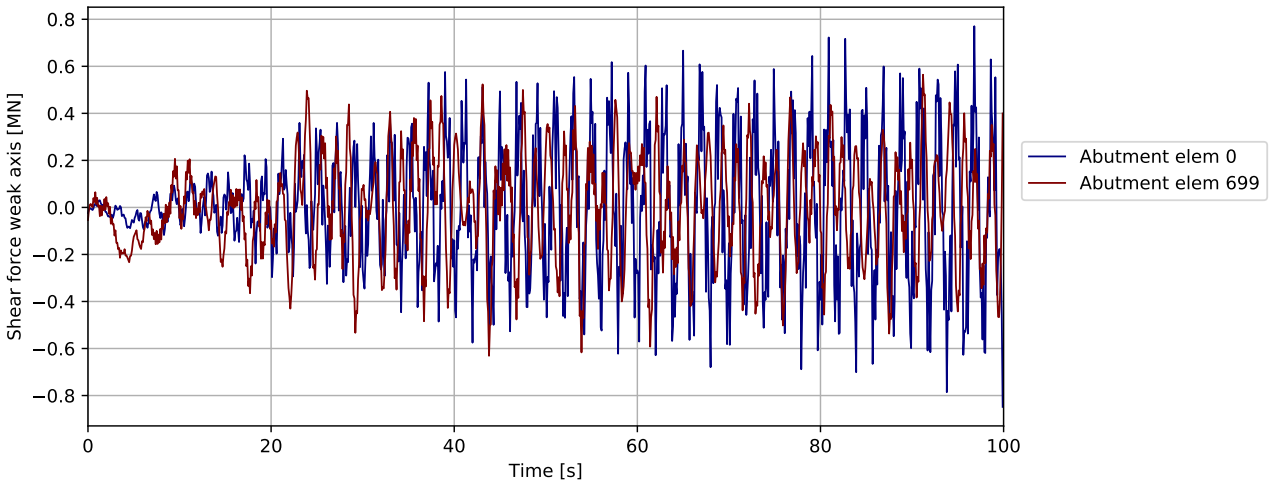

Figure 3.176: P A10 0deg - bridgegirder @abutments: Shear force weak axis [MN]

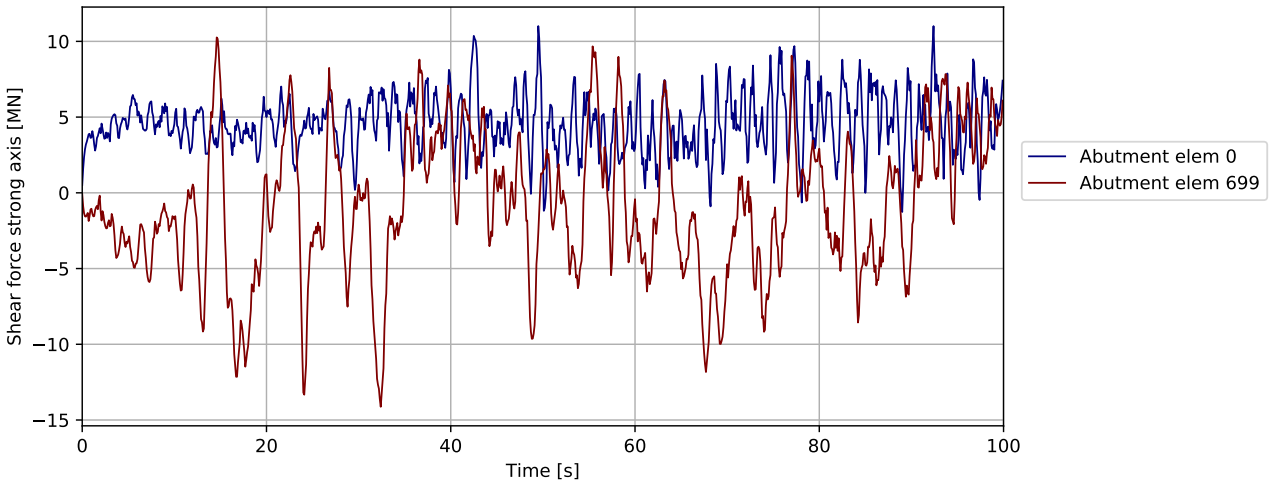

Figure 3.177: P A10 0deg - bridgegirder @abutments: Shear force strong axis [MN]

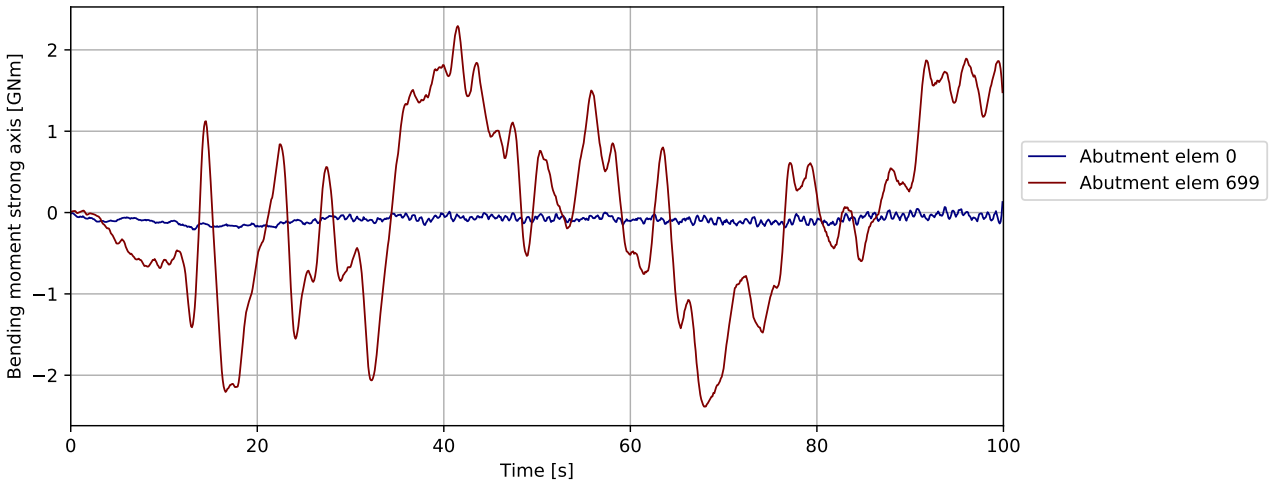

Figure 3.178: P A10 0deg - bridgegirder @abutments: Bending moment strong axis [GNm]

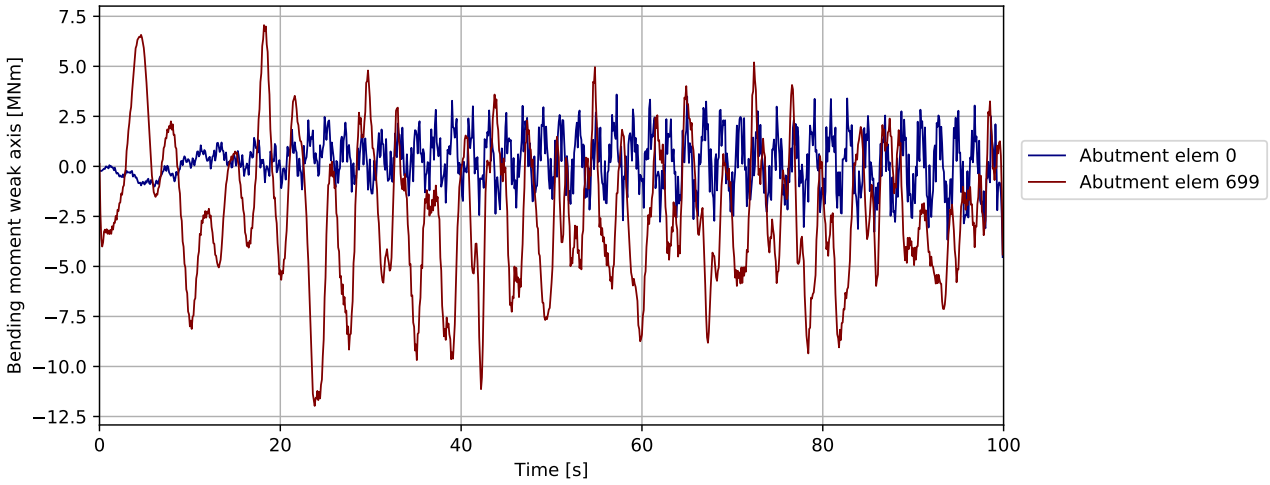

Figure 3.179: P A10 0deg - bridgegirder @abutments: Bending moment weak axis [MNm]

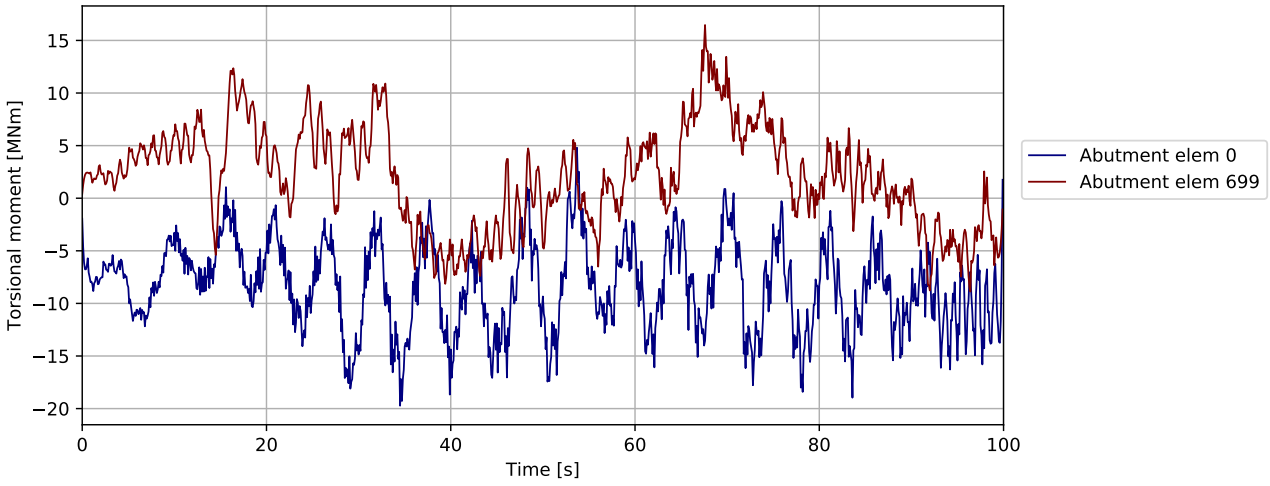

Figure 3.180: P A10 0deg - bridgegirder @abutments: Torsional moment [MNm]

Note : Compressive spring force is negative

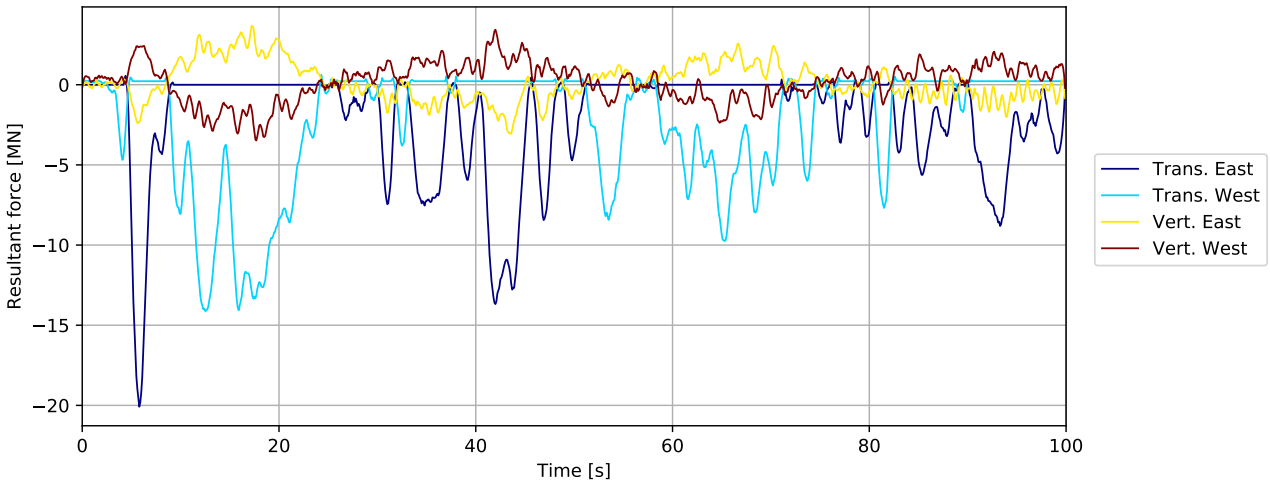

Figure 3.181: P A10 0deg - bridgegirder supports in tower: Resultant force [MN]

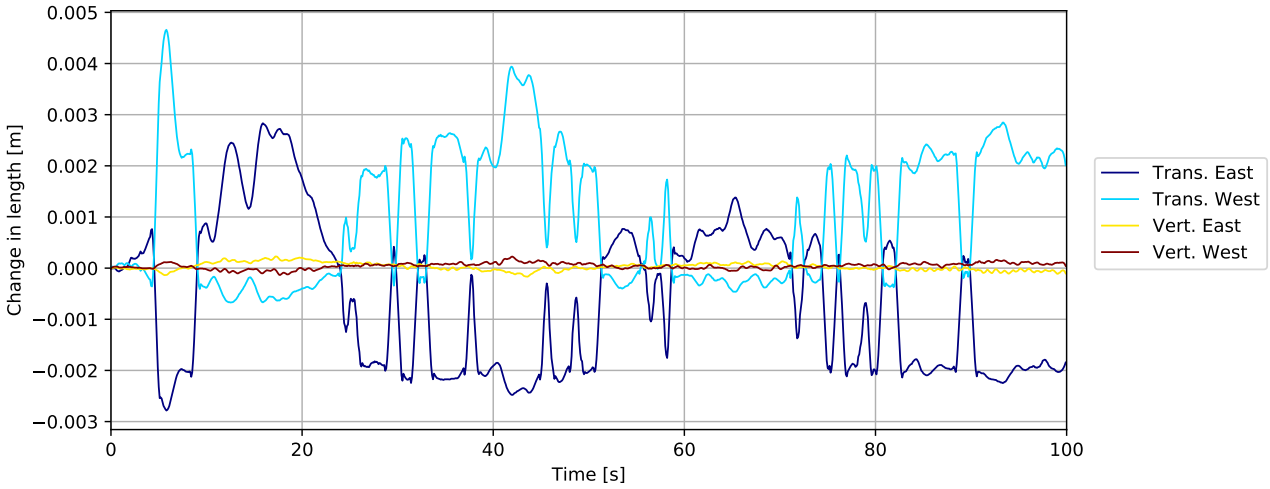

Figure 3.182: P A10 0deg - bridgegirder supports in tower: Change in length [m]

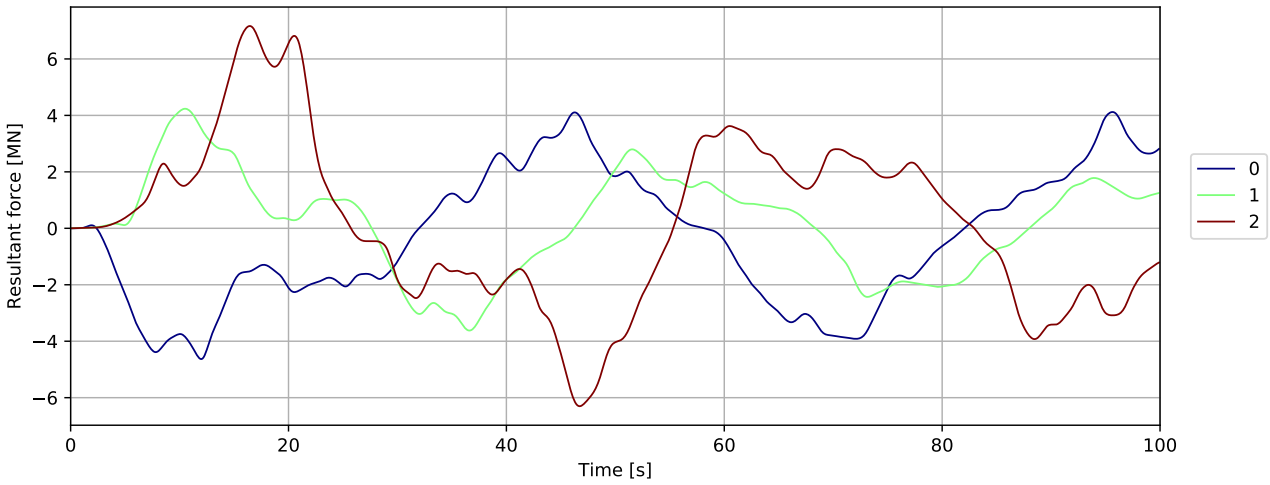

Figure 3.183: Mooring force

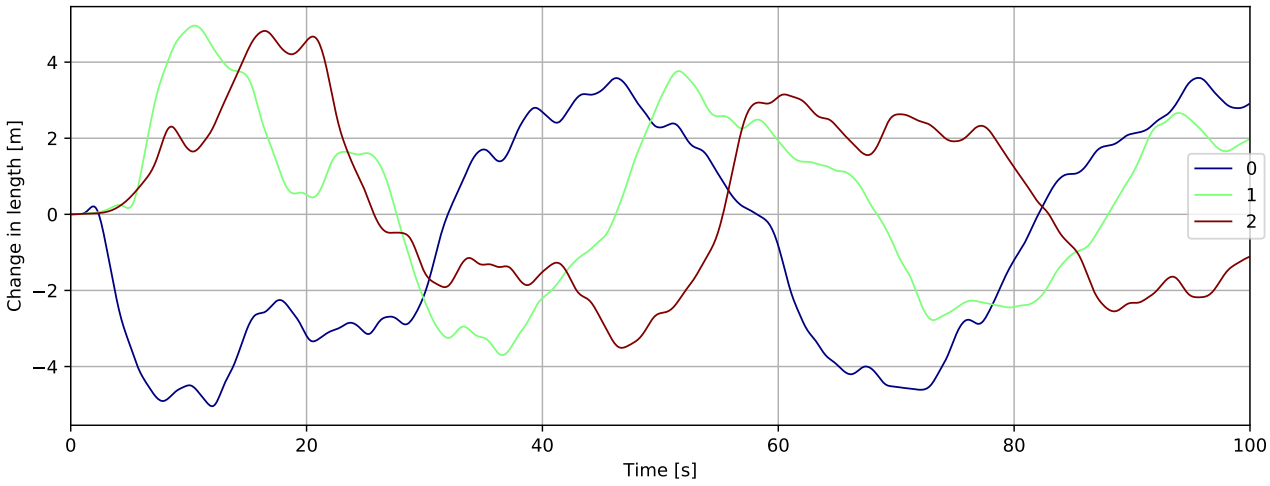

Figure 3.184: Mooring displacement

3.5 PontoonA20 0deg

3.5.1 Overall response

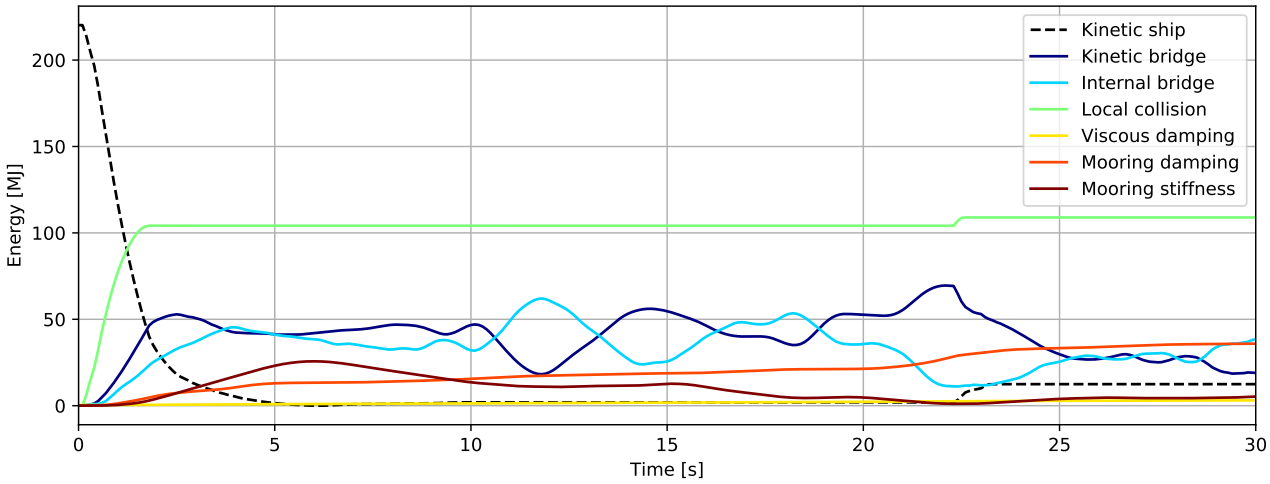

Figure 3.185: Energy [MJ] - initial phase

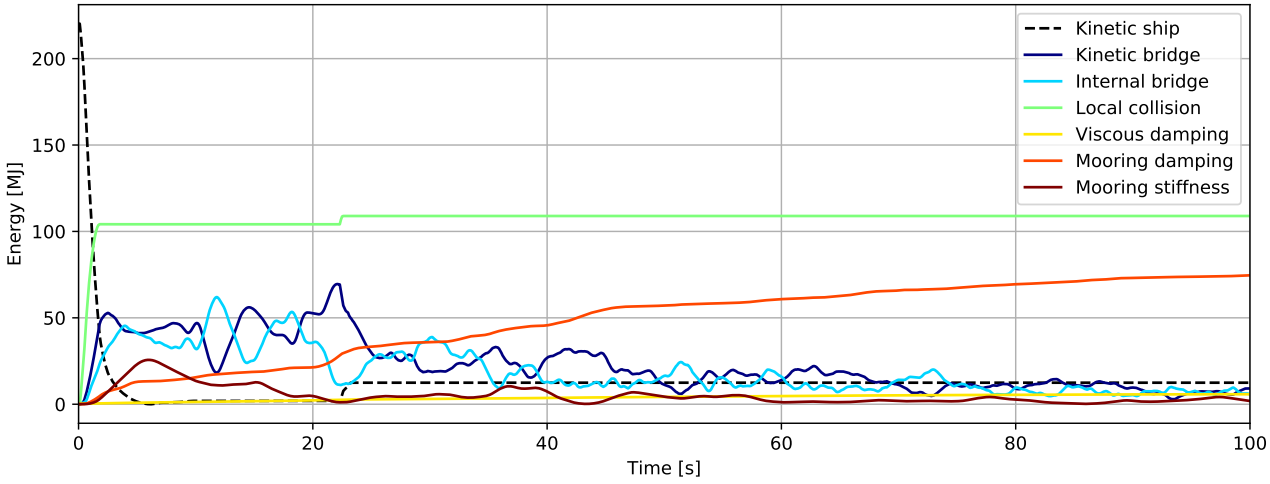

Figure 3.186: Energy [MJ]

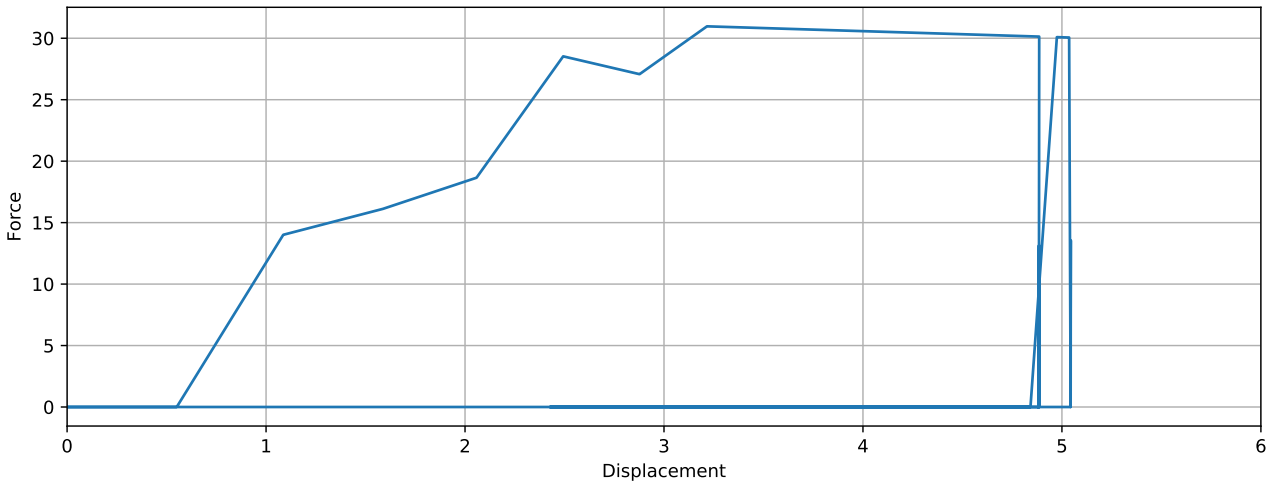

Figure 3.187: Simulated local collision force-displacement

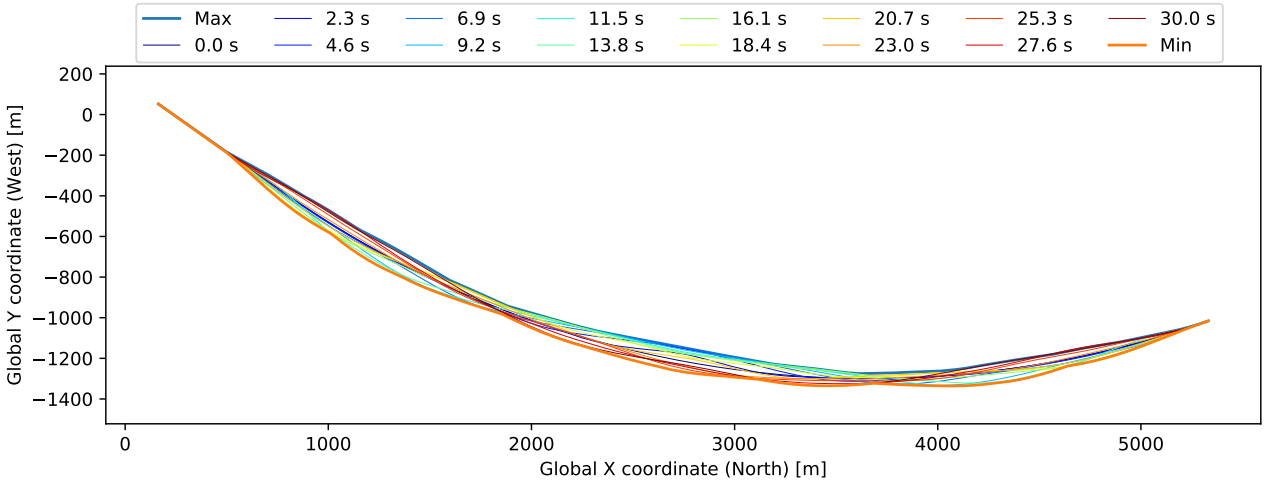

Figure 3.188: Bridgegirder deflection (10x displacment scaling)

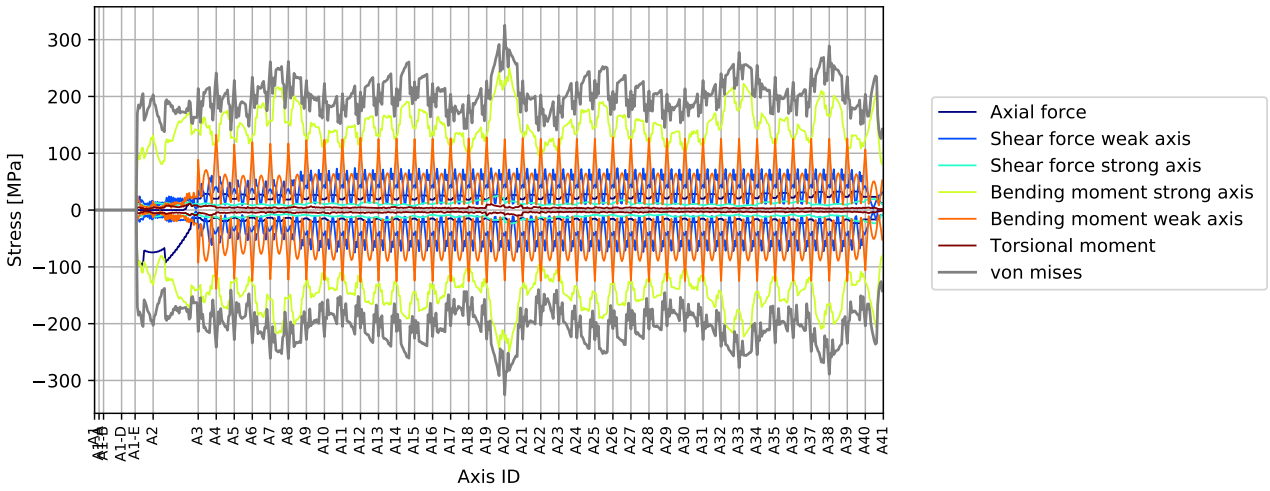

Figure 3.189: Stress envelope from all force components

3.5.2 Envelope plots

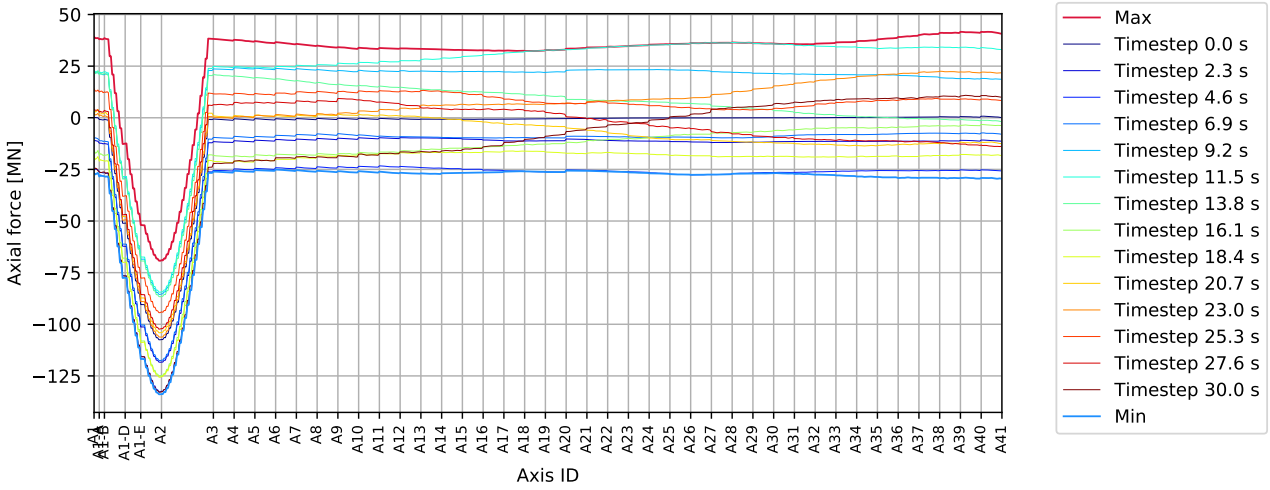

Figure 3.190: P A20 0deg - bridgegirder : Axial force [MN]

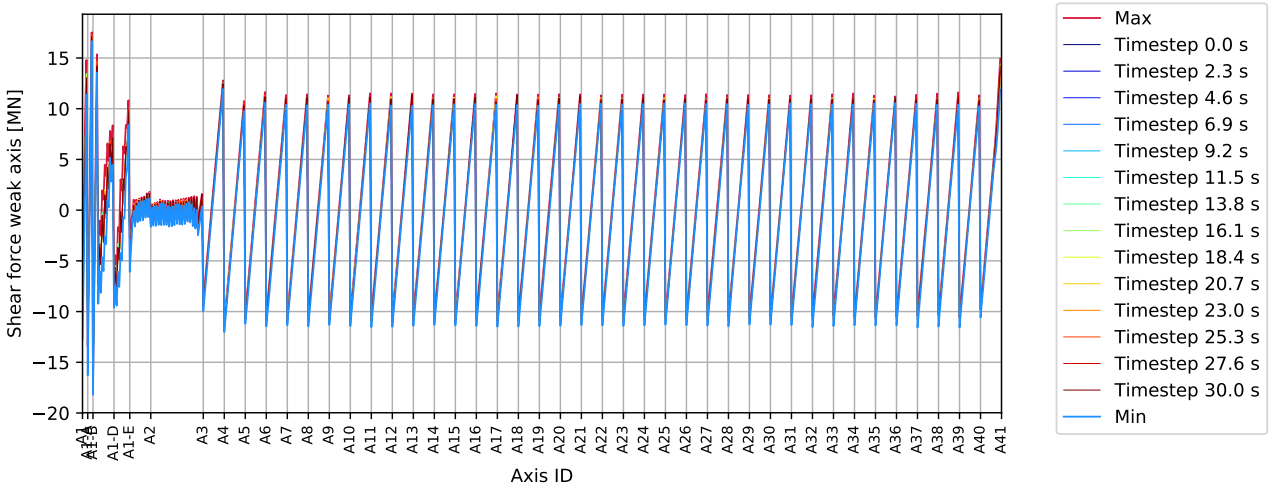

Figure 3.191: P A20 0deg - bridgegirder : Shear force weak axis [MN]

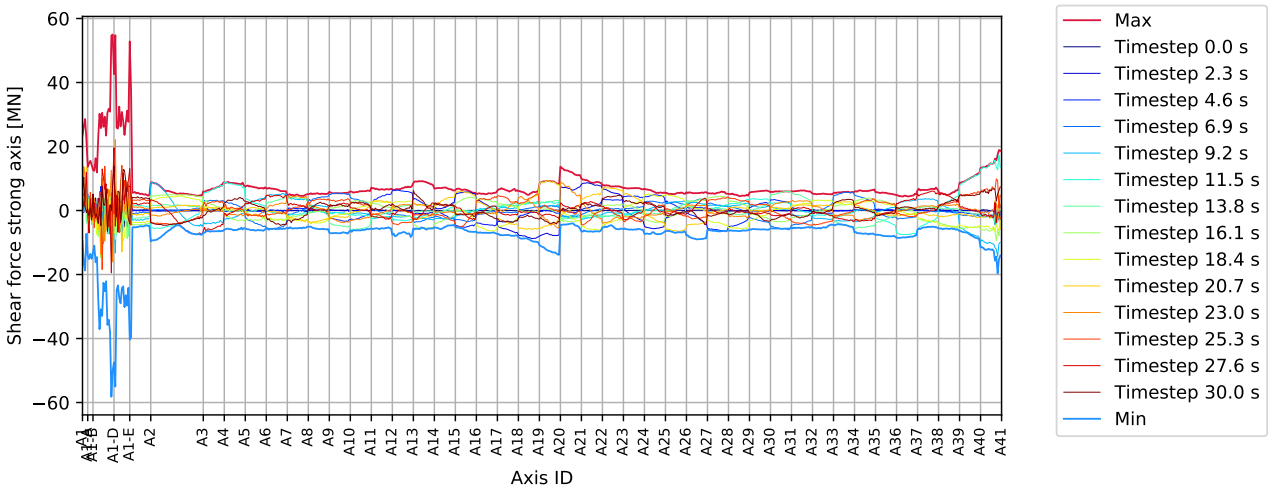

Figure 3.192: P A20 0deg - bridgegirder : Shear force strong axis [MN]

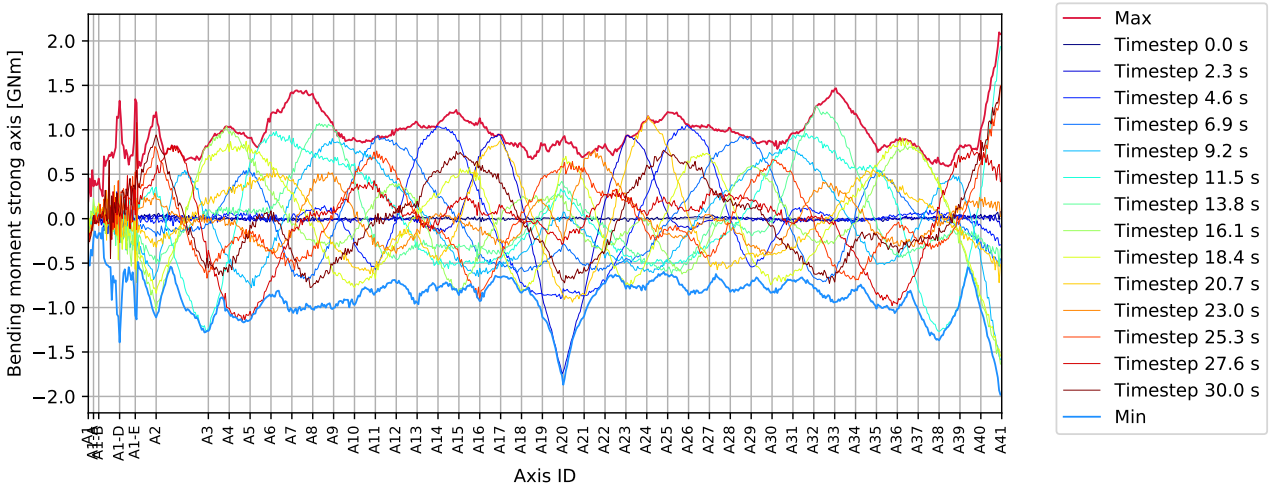

Figure 3.193: P A20 0deg - bridgegirder : Bending moment strong axis [GNm]

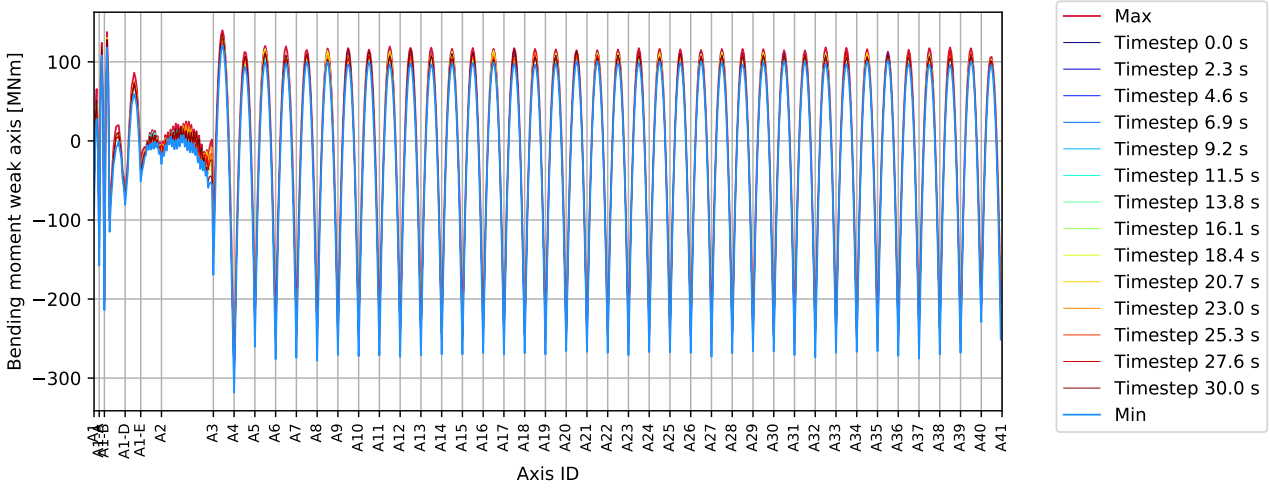

Figure 3.194: P A20 0deg - bridgegirder : Bending moment weak axis [MNm]

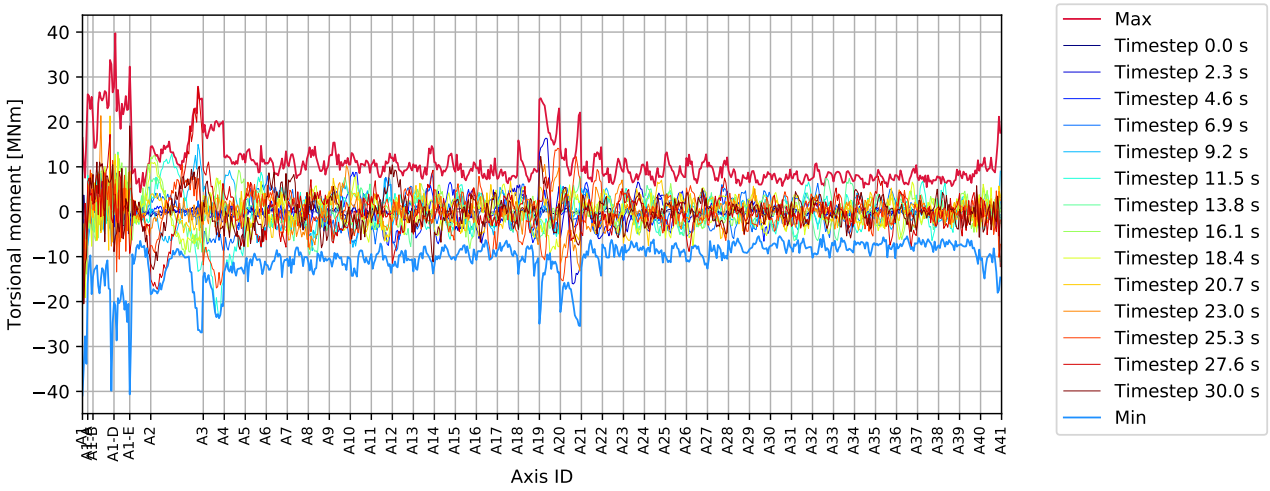

Figure 3.195: P A20 0deg - bridgegirder : Torsional moment [MNm]

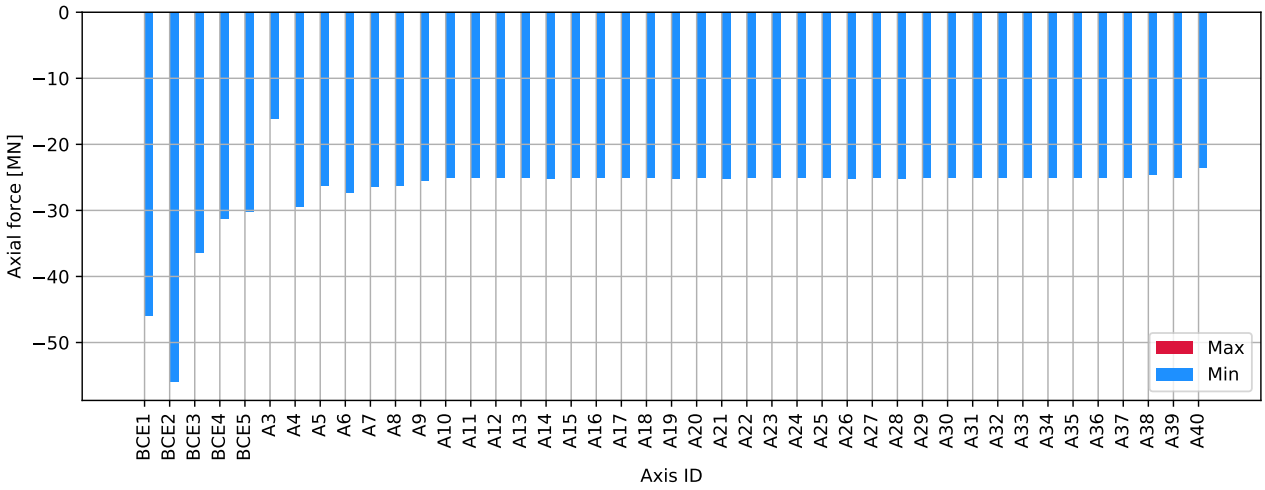

Figure 3.196: P A20 0deg - columns bottom : Axial force [MN]

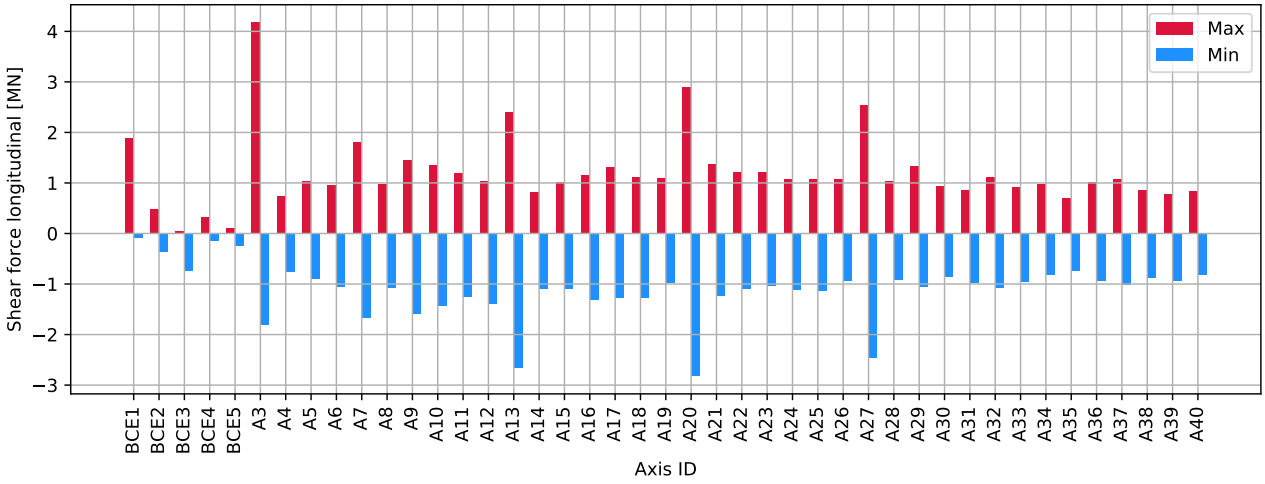

Figure 3.197: P A20 0deg - columns bottom : Shear force longitudinal [MN]

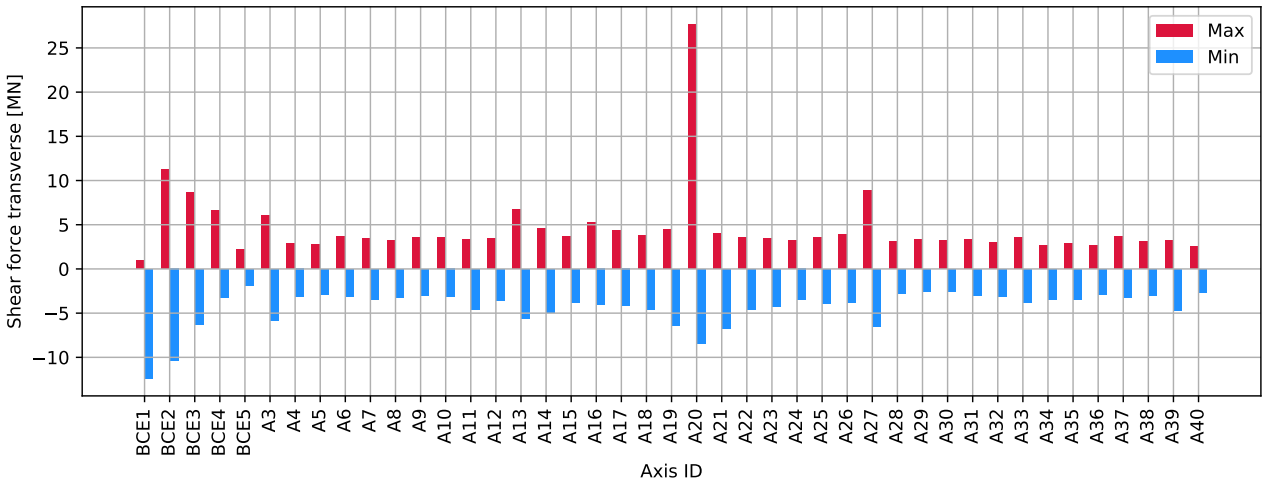

Figure 3.198: P A20 0deg - columns bottom : Shear force transverse [MN]

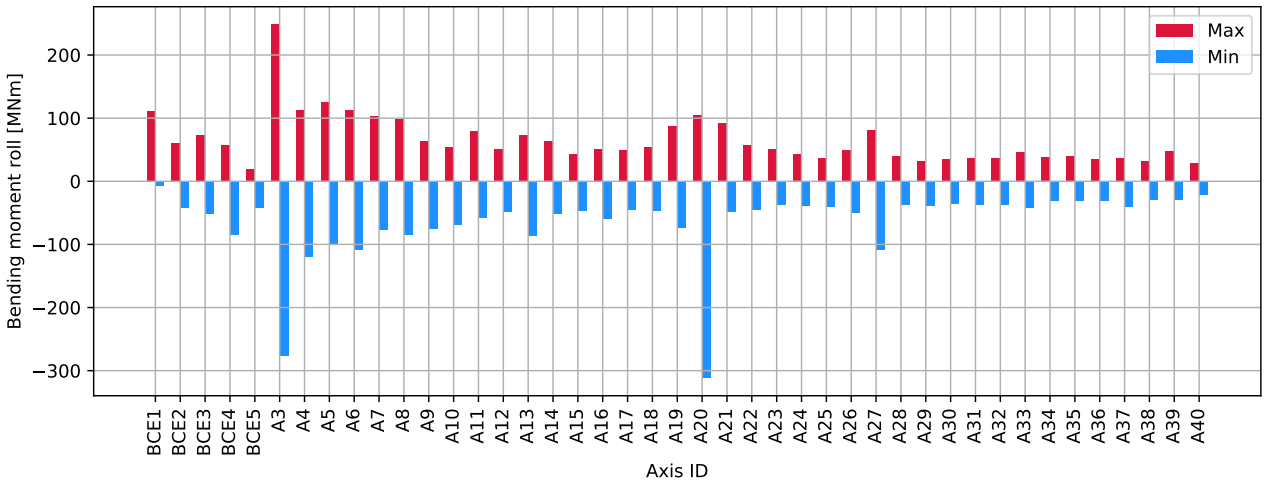

Figure 3.199: P A20 0deg - columns bottom : Bending moment roll [MNm]

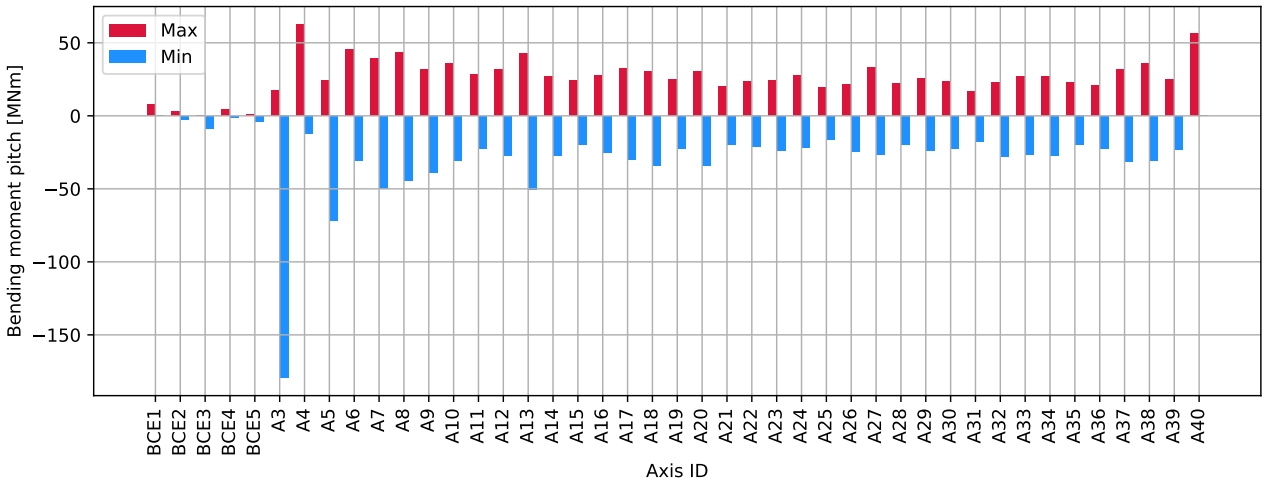

Figure 3.200: P A20 0deg - columns bottom : Bending moment pitch [MNm]

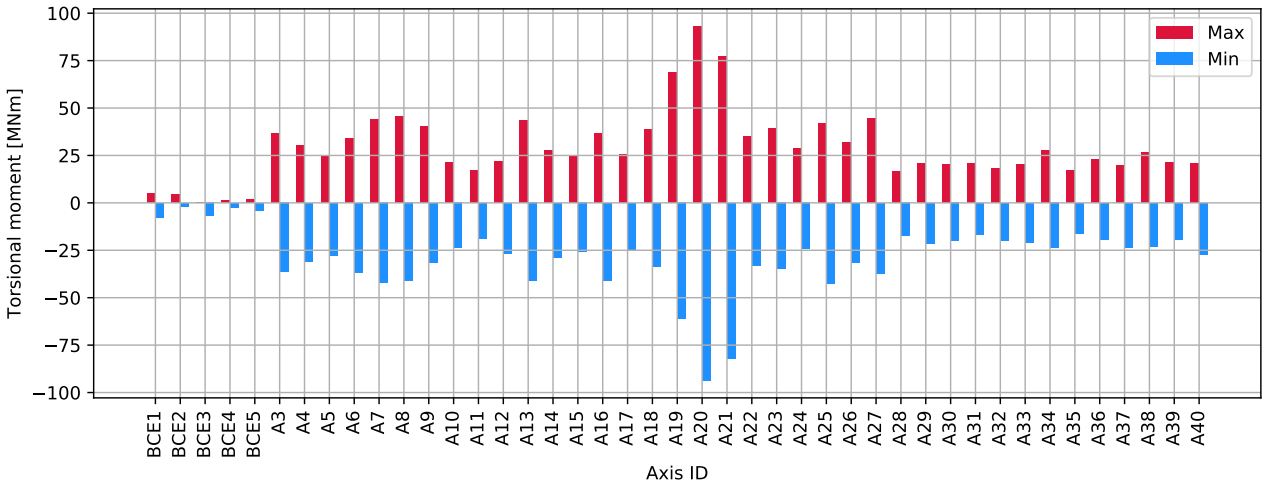

Figure 3.201: P A20 0deg - columns bottom : Torsional moment [MNm]

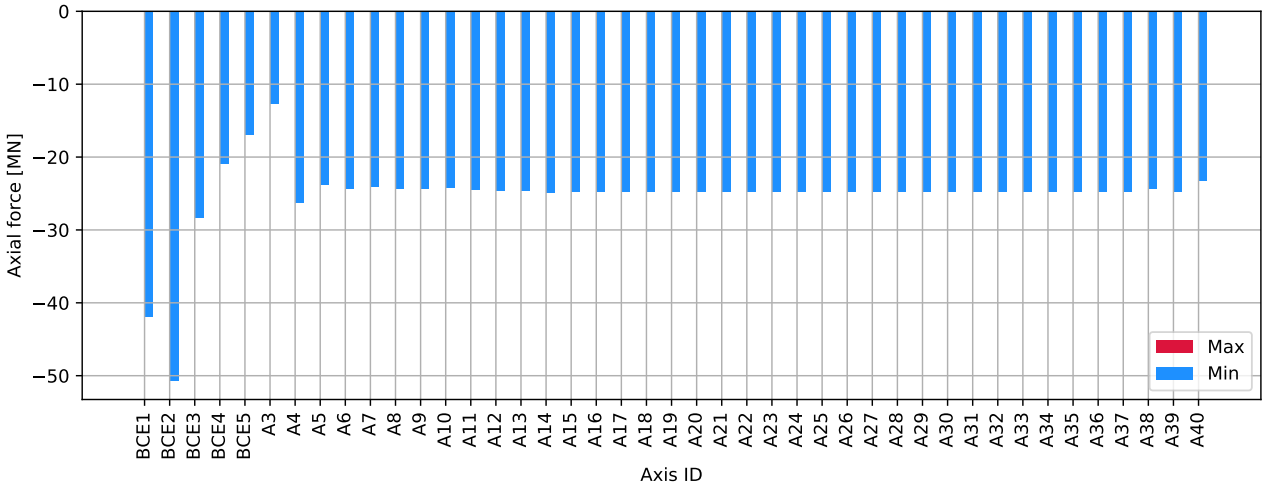

Figure 3.202: P A20 0deg - columns top : Axial force [MN]

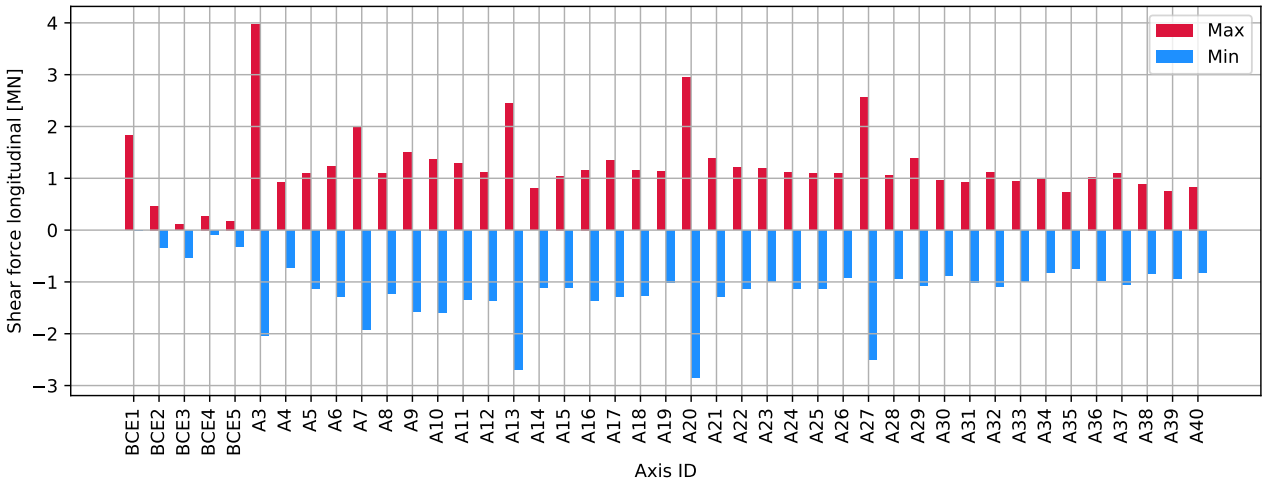

Figure 3.203: P A20 0deg - columns top : Shear force longitudinal [MN]

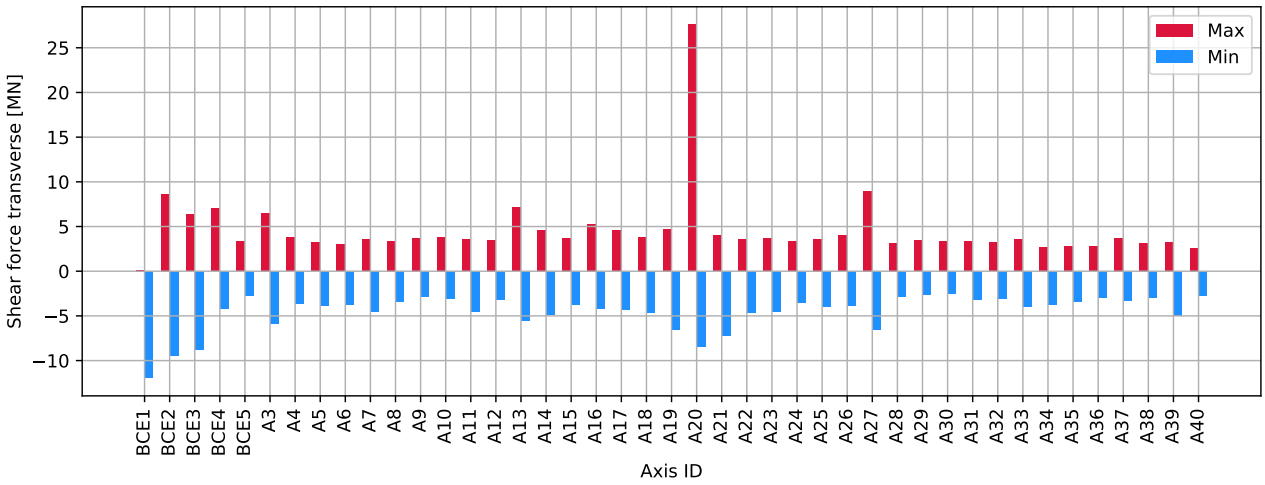

Figure 3.204: P A20 0deg - columns top : Shear force transverse [MN]

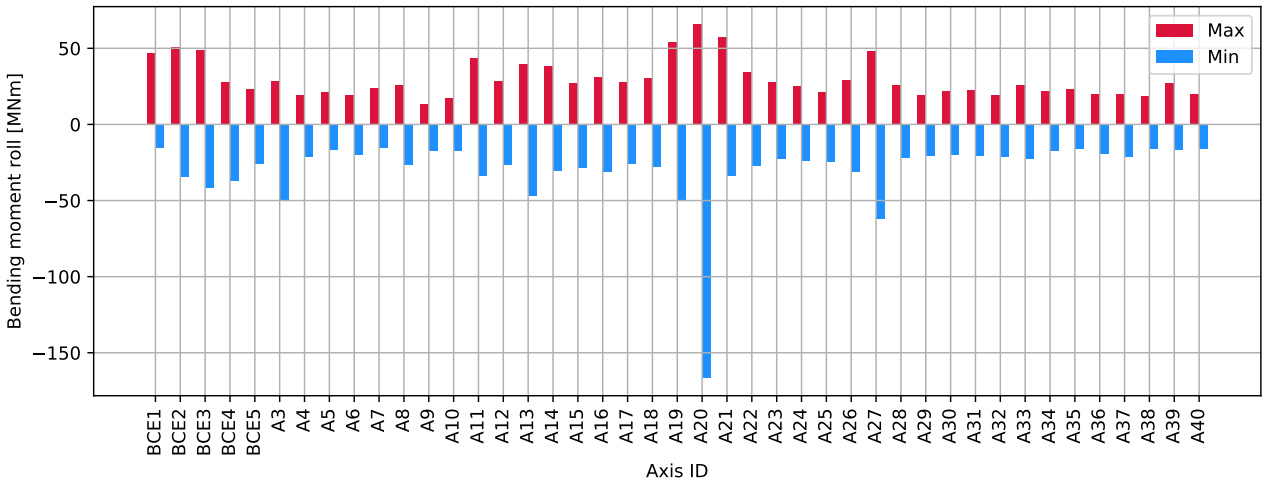

Figure 3.205: P A20 0deg - columns top : Bending moment roll [MNm]

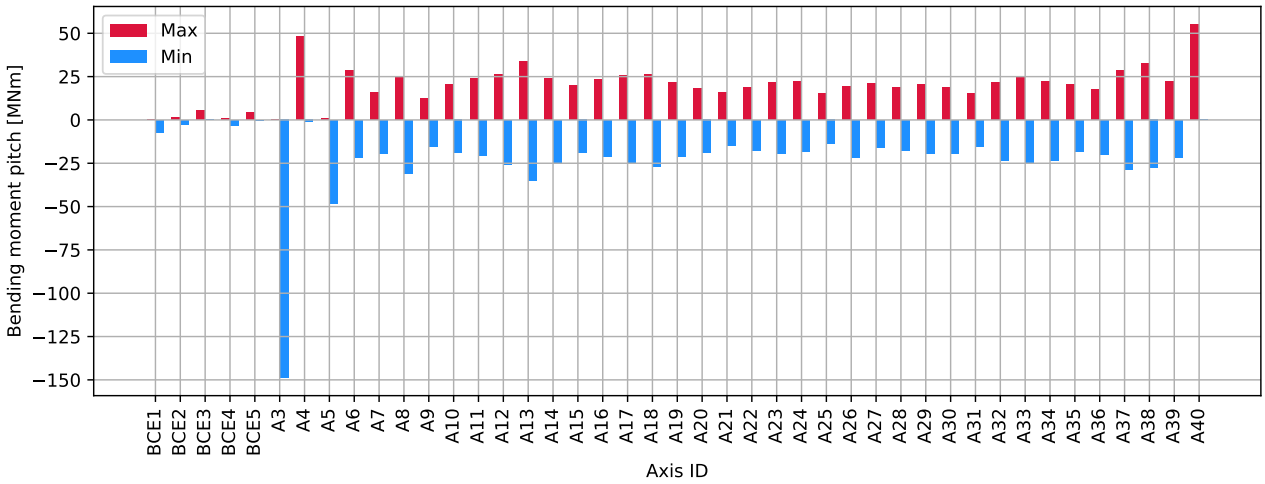

Figure 3.206: P A20 0deg - columns top : Bending moment pitch [MNm]