Appendix to report:

SBJ-33-C5-OON-22-RE-016

FATIGUE ASSESSMENT

Appendix title:

Appendix C – Detailed results, section data and pairplots

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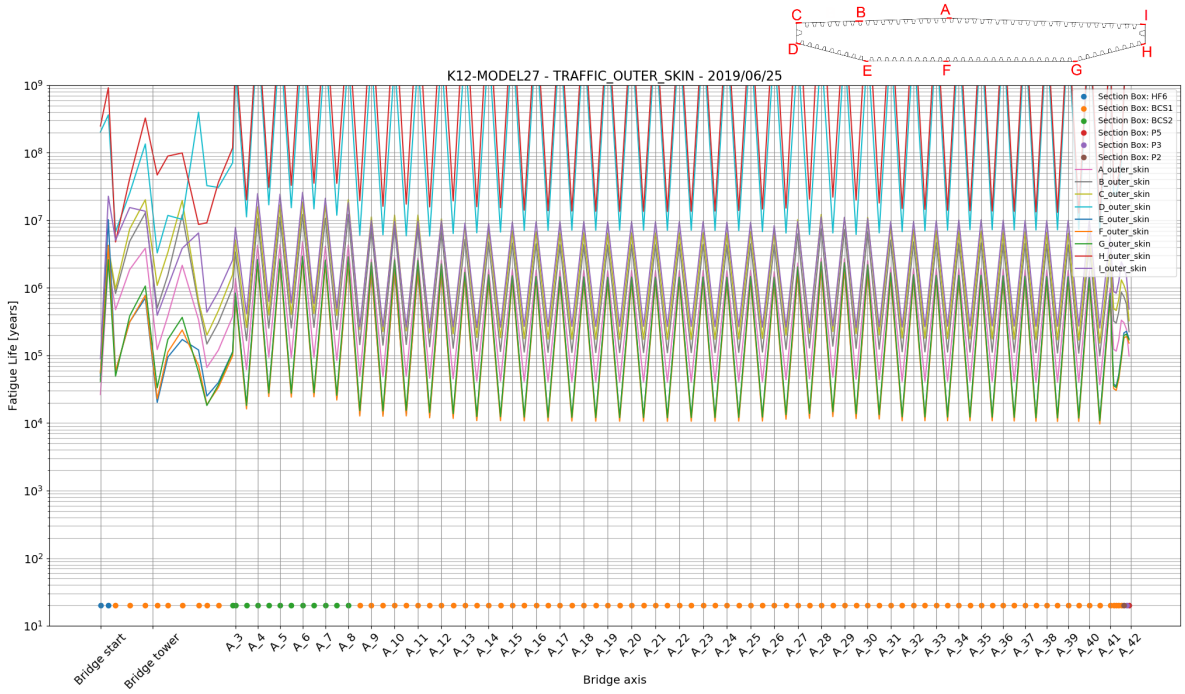
CONCEPT DEVELOPMENT FLOATING BRIDGE E39 BJØRNAFJORDEN

Table of Content

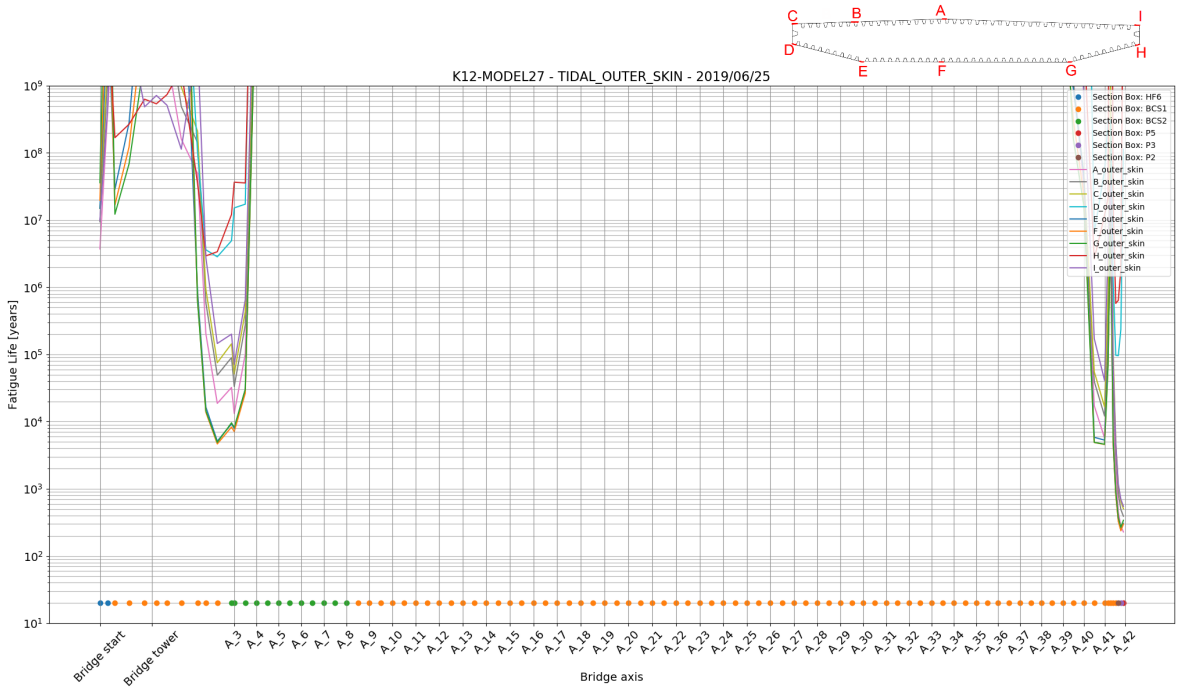
1 DETAILED RESULTS FATIGUE CALCULATIONS

Plots for separate global load types such as traffic, tide, swell, wind and wind-sea are shown in this appendix. Furthermore, stress transfer factors and cross-section parameters for all cross-sections are shown.

1.1 Bridge girder outer skin: traffic and tidal

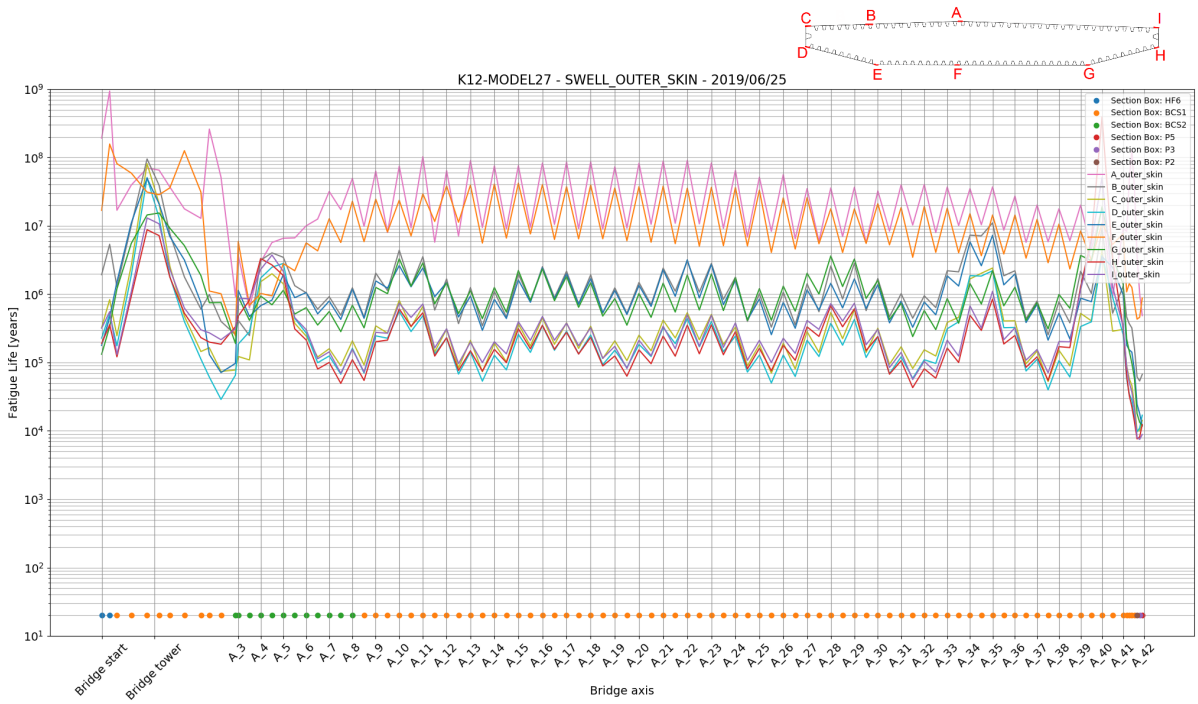


> *Figure 1: Outer skin fatigue life plot from global traffic condition*



> *Figure 2: Outer skin fatigue life plot from tidal condition*

1.2 Bridge girder outer skin: Swell, wind and wind sea



> *Figure 3: Outer skin fatigue life plot from swell condition*

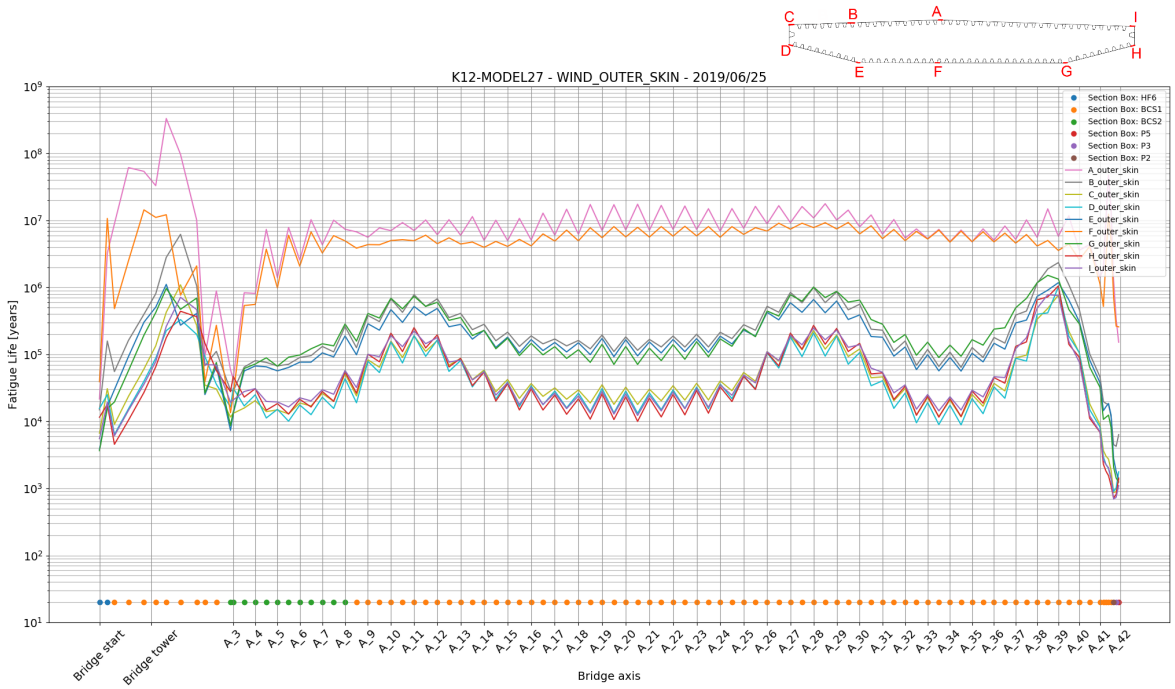


Figure 4: Outer skin fatigue life plot from wind condition

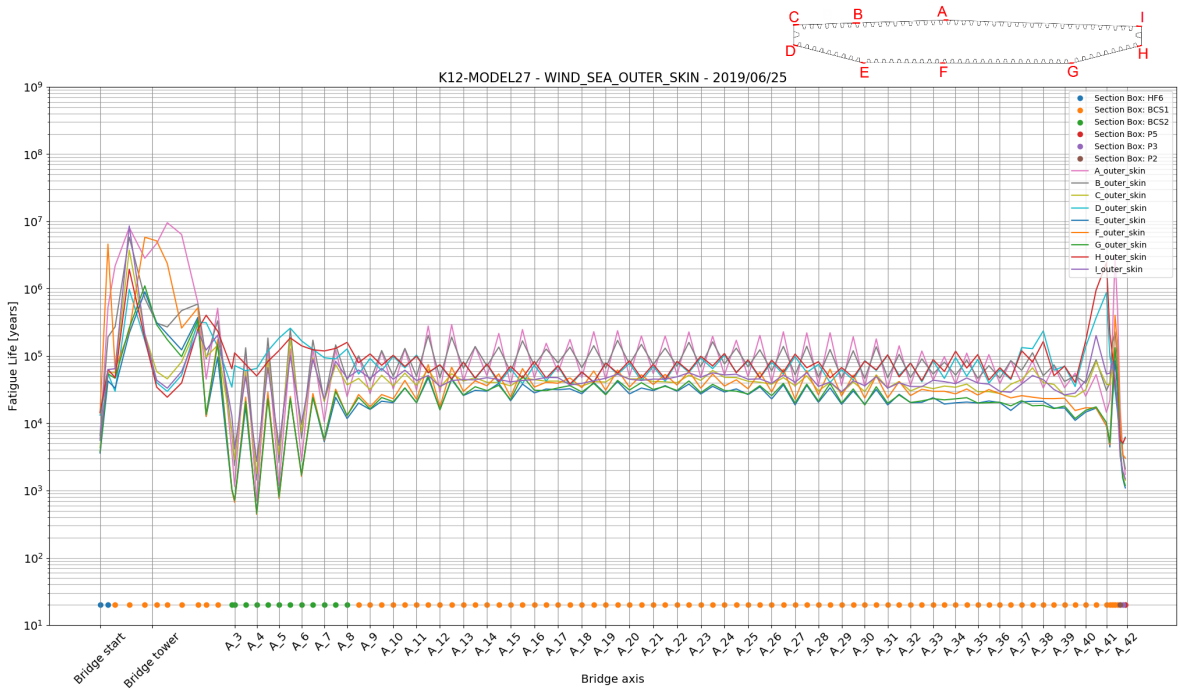


Figure 5: Outer skin fatigue life plot from wind sea condition

1.3 Bridge girder outer skin: environmental

(combination case of wind, swell and wind-sea)

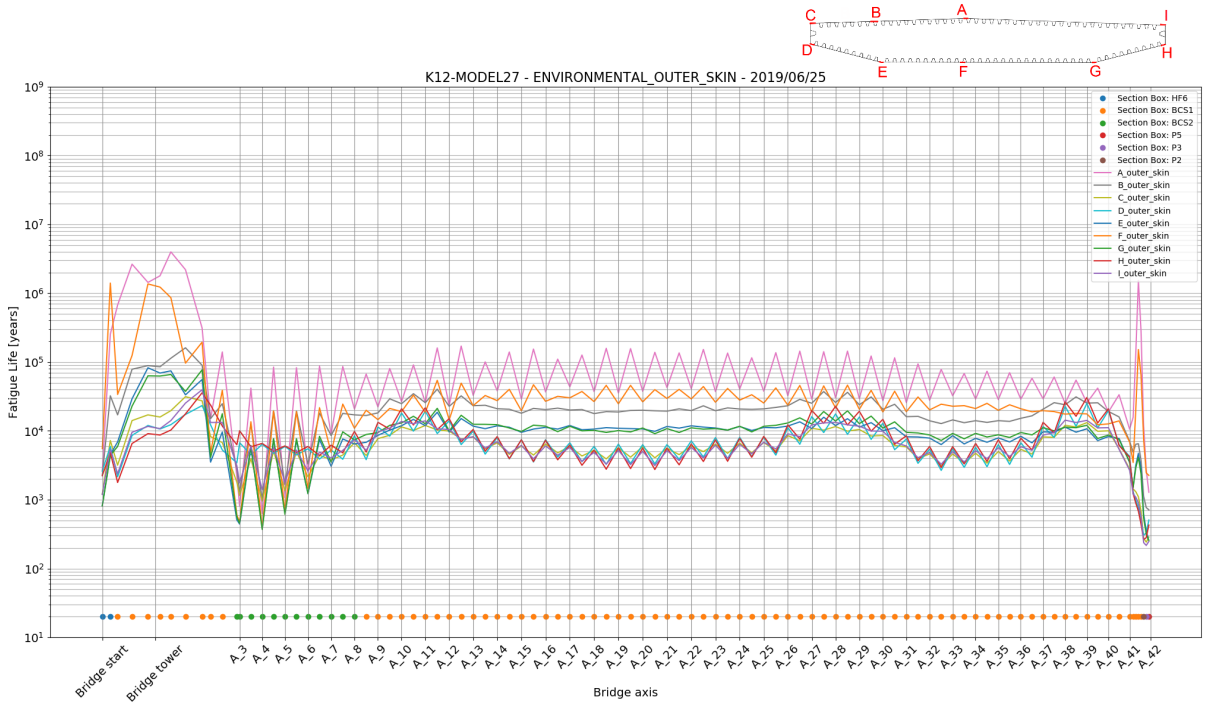


Figure 6: Outer skin fatigue life plot from environmental condition

1.4 Trapezoidal stiffener: traffic and tidal

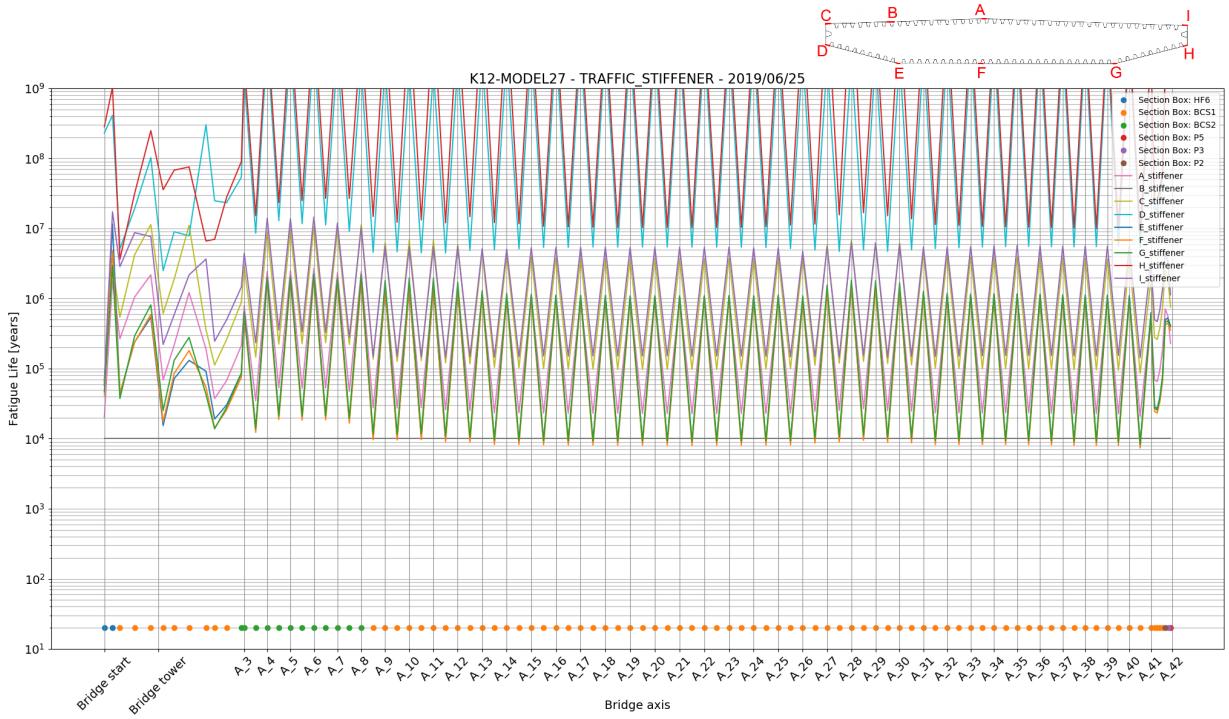
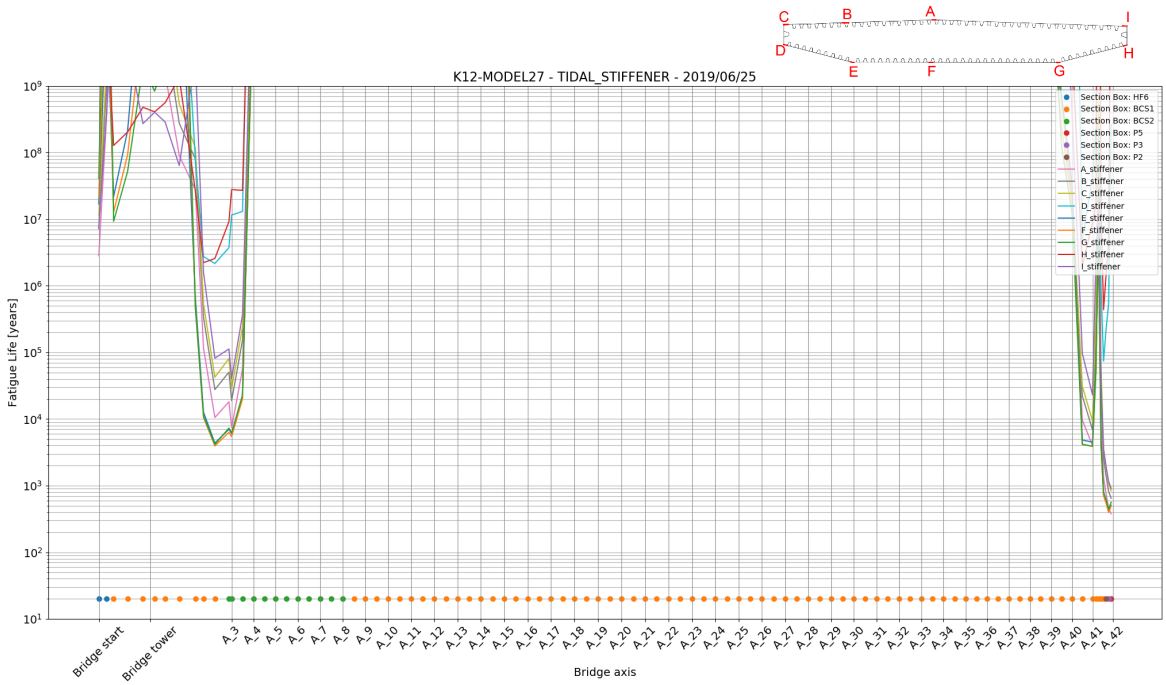
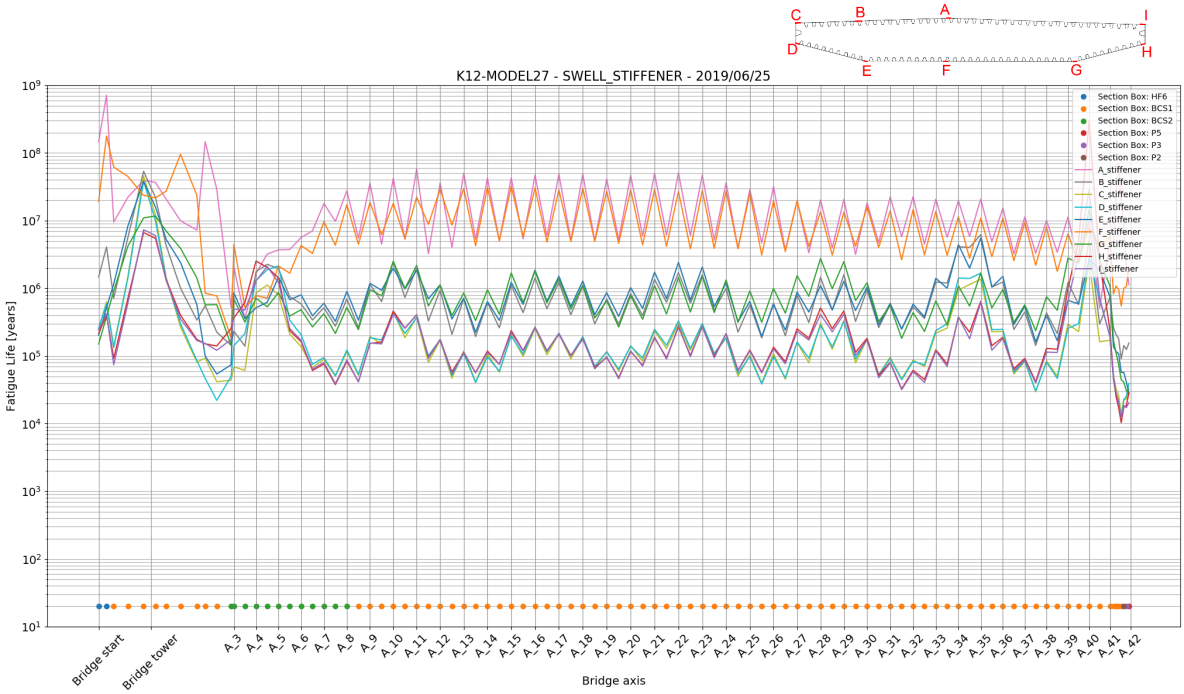


Figure 7: Stiffener fatigue life plot from global traffic condition

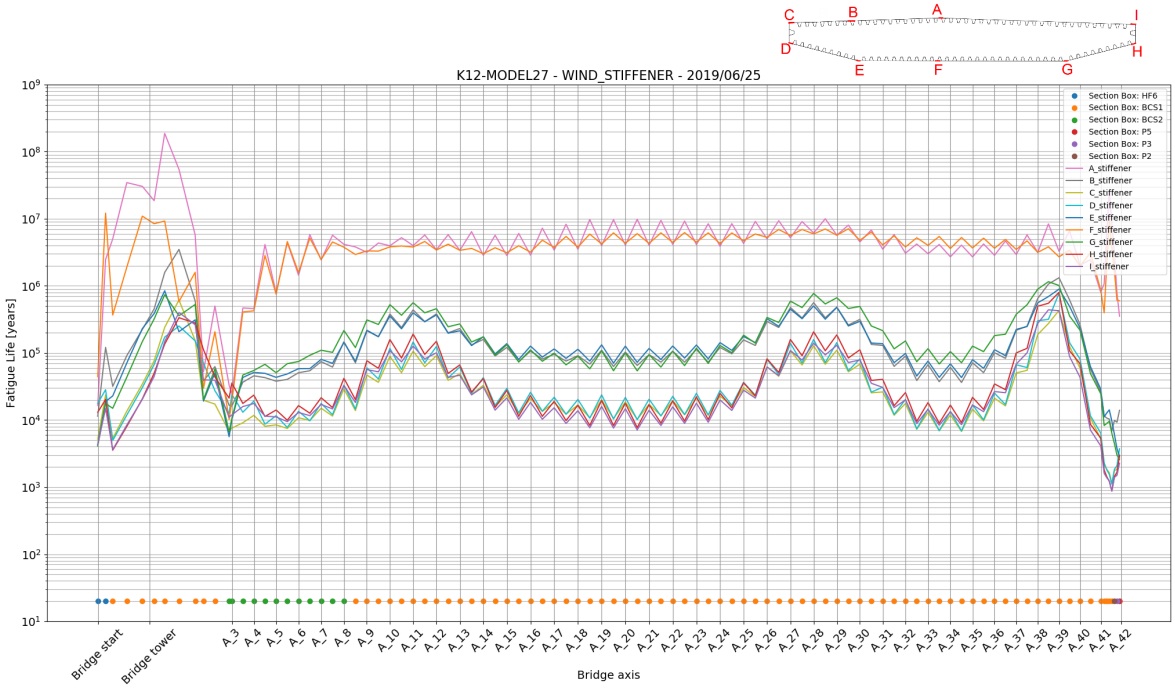


> *Figure 8: Stiffener fatigue life plot from tidal condition*

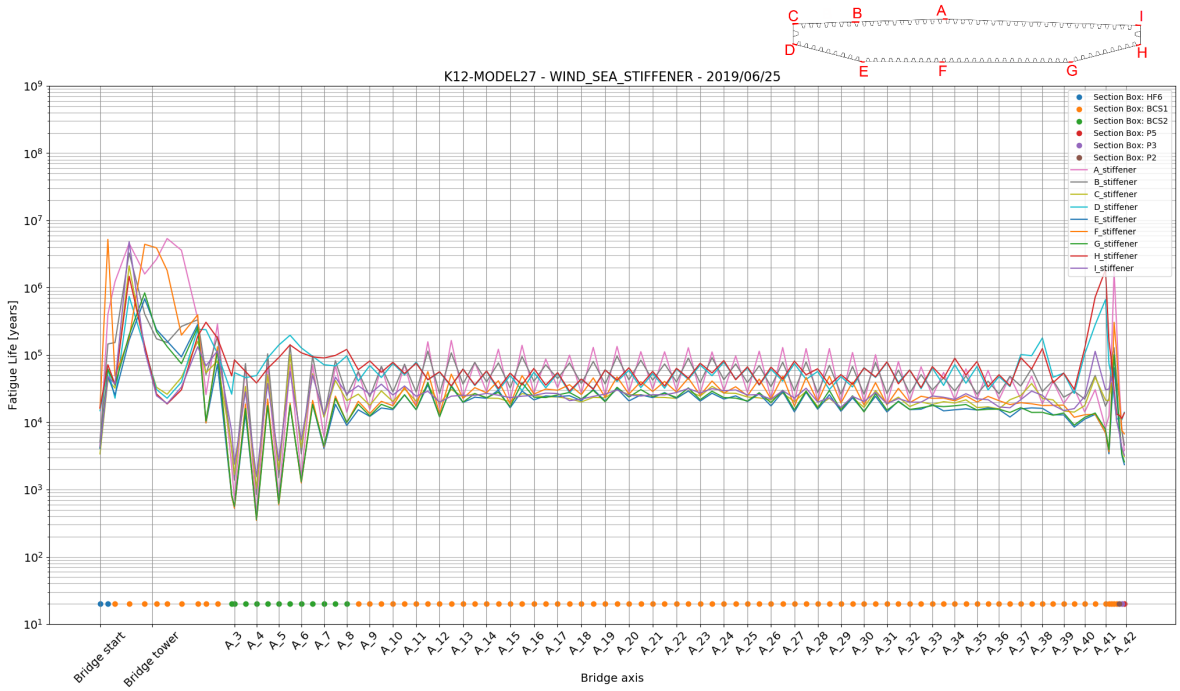
1.5 Trapezoidal stiffener: swell, wind and wind sea



> *Figure 9: Stiffener fatigue life plot from swell condition*



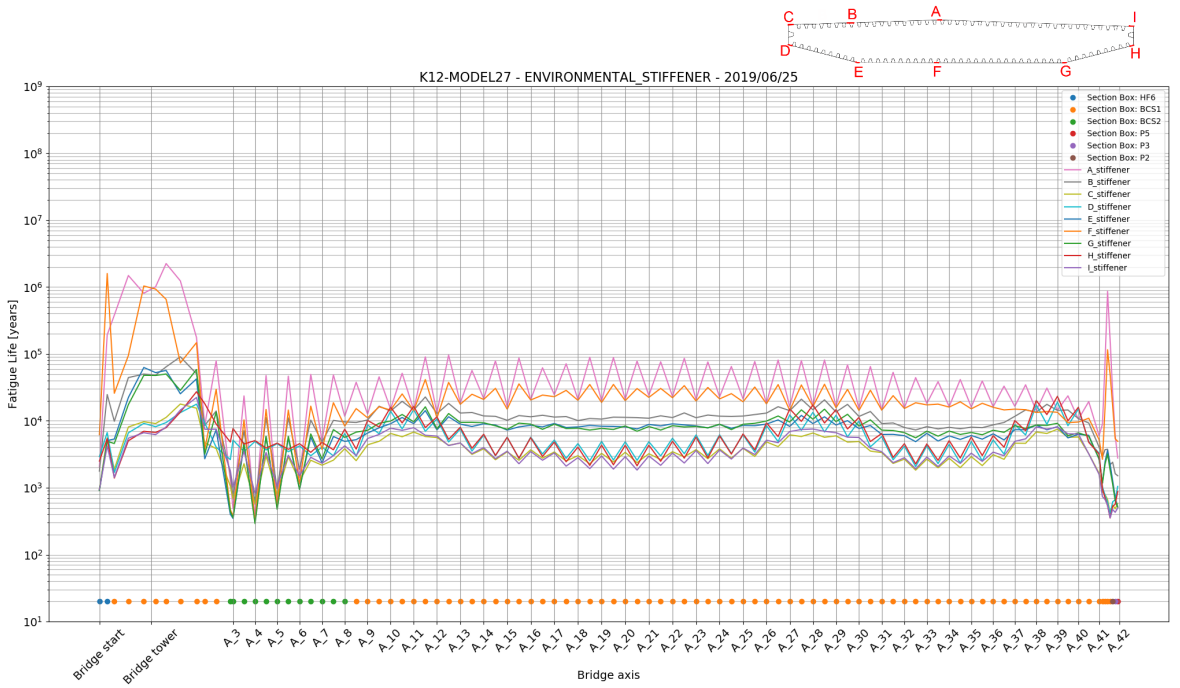
> *Figure 10: Stiffener fatigue life plot from wind condition*



> *Figure 11: Stiffener fatigue life plot from wind sea condition*

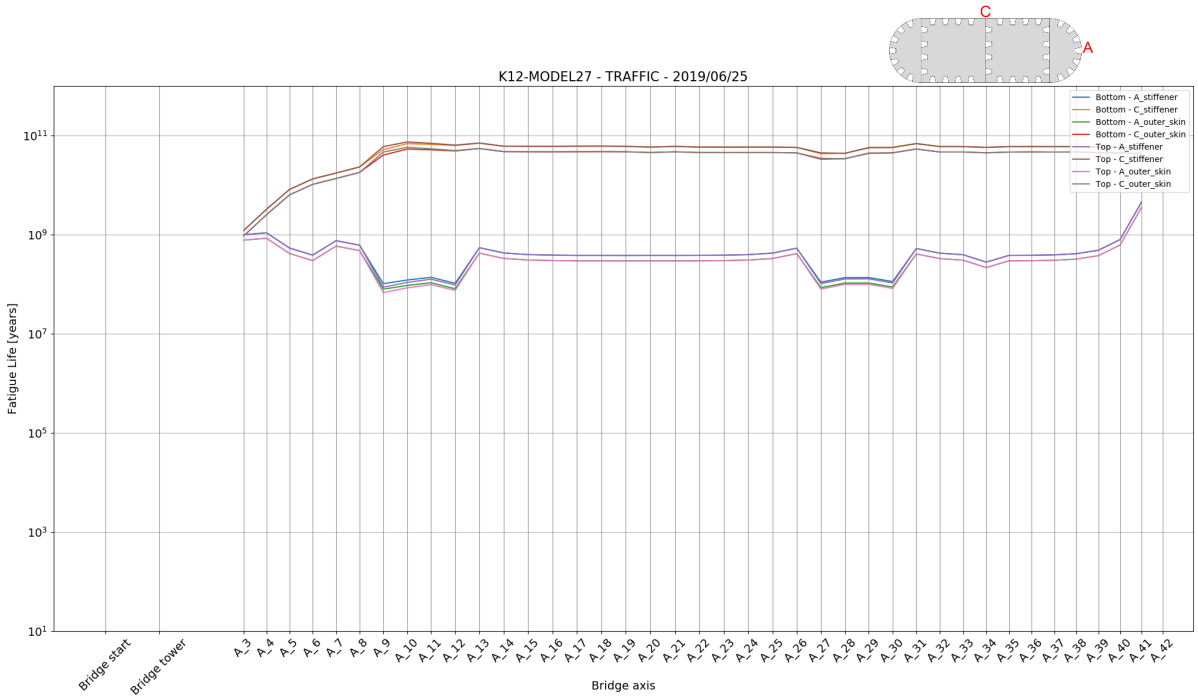
1.6 Trapezoidal stiffener: environmental

(combination of wind, swell and wind-sea)

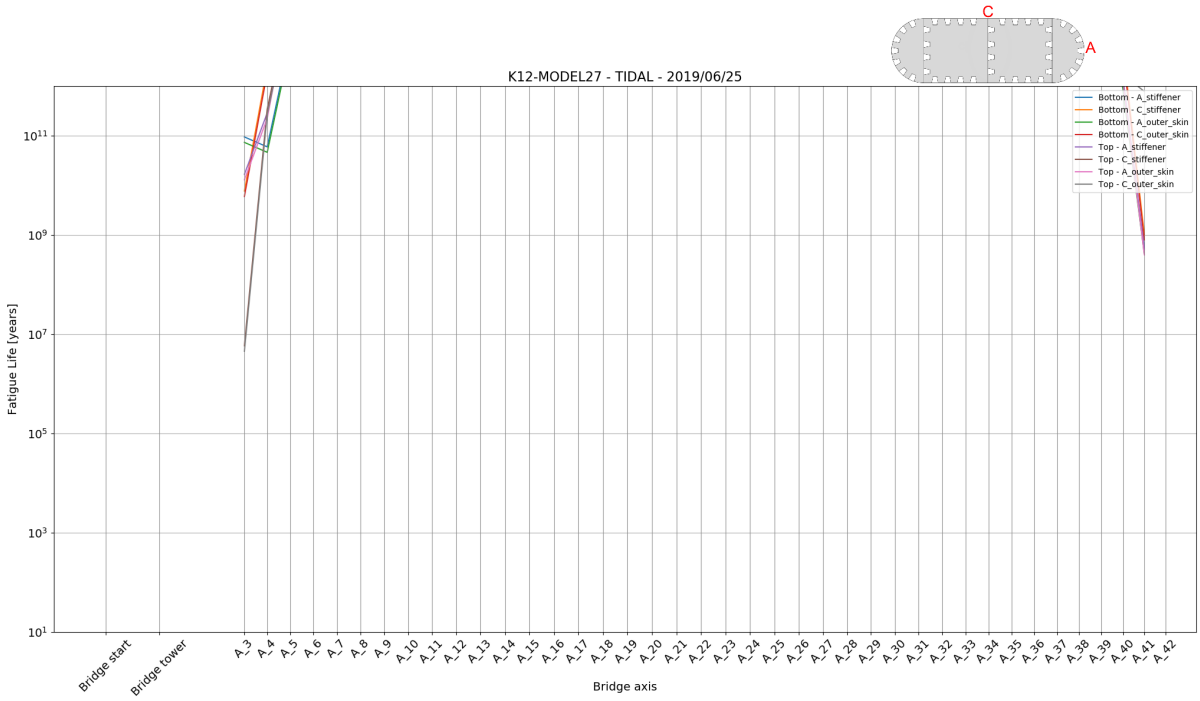


> *Figure 12: Stiffener fatigue life plot from environmental condition*

1.7 Bridge column: traffic and tidal



> *Figure 13: Column fatigue life plot from global traffic condition*



> *Figure 14: Column fatigue life plot from tidal condition*

1.8 Bridge column: swell, wind and wind sea

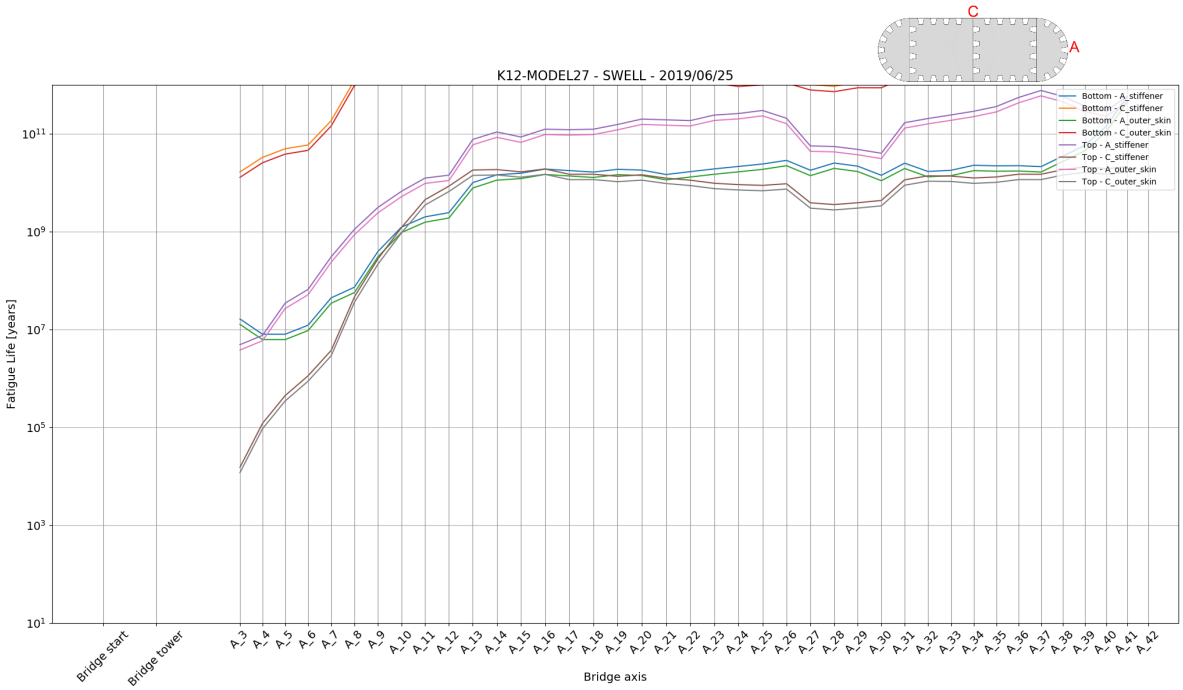


Figure 15: Column fatigue life plot from swell condition

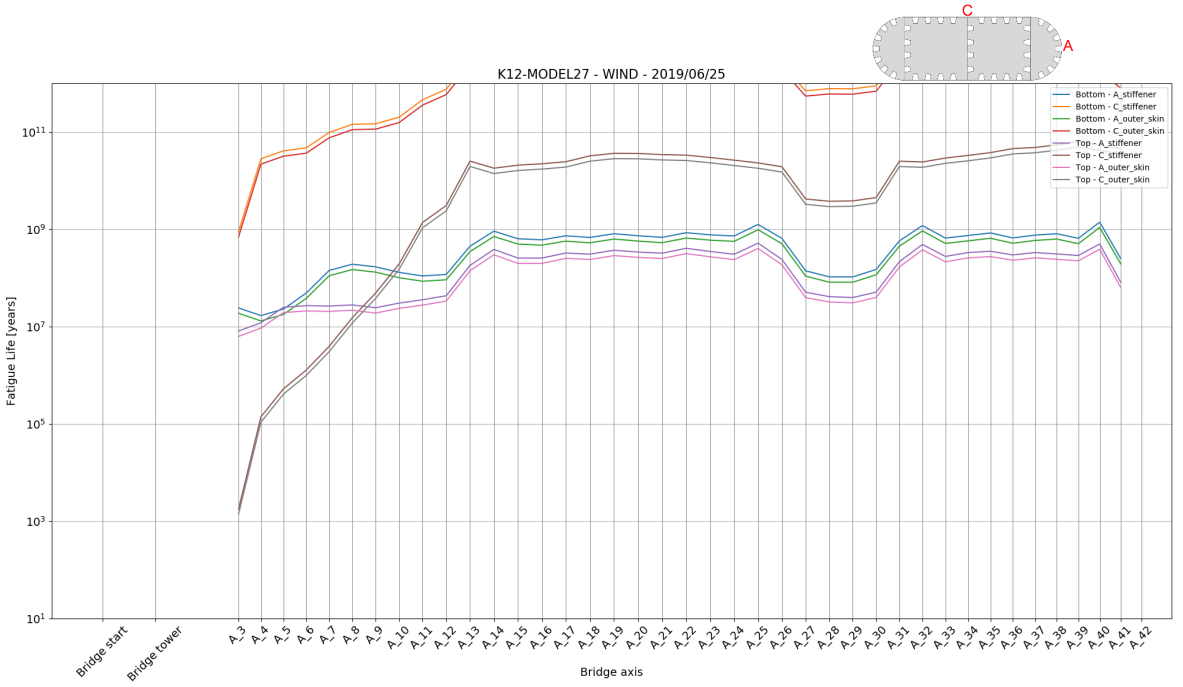


Figure 16: Column fatigue life plot from wind condition

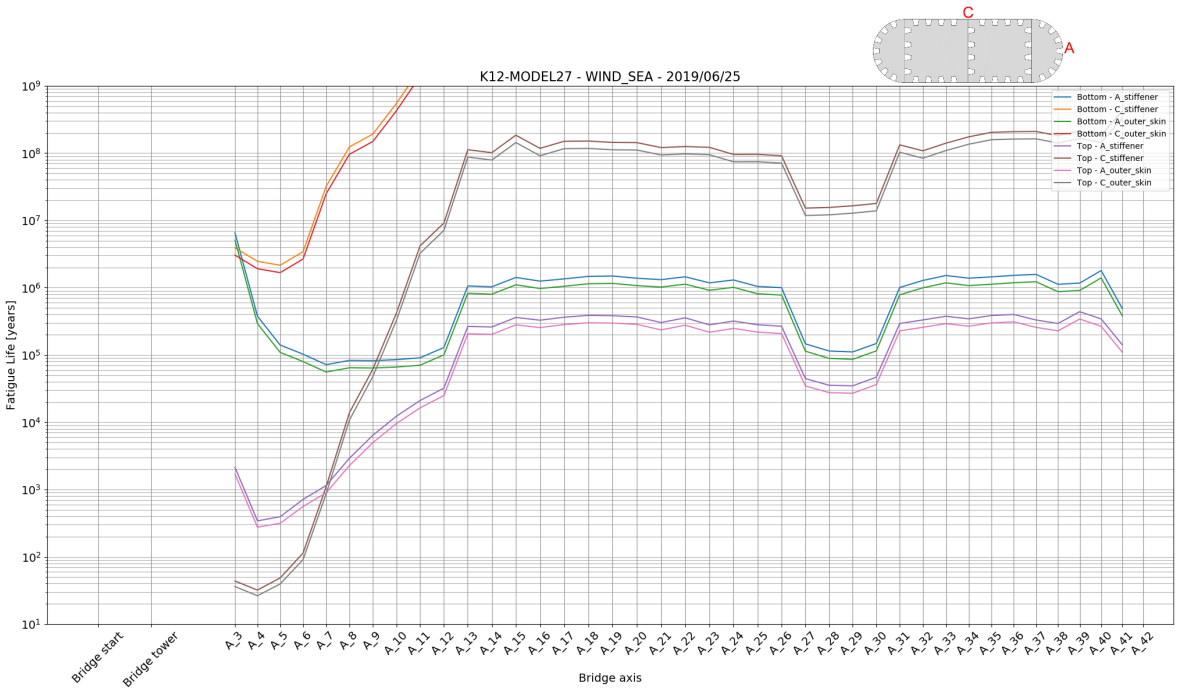


Figure 17: Column fatigue life plot from wind sea condition

1.9 Bridge column: environmental

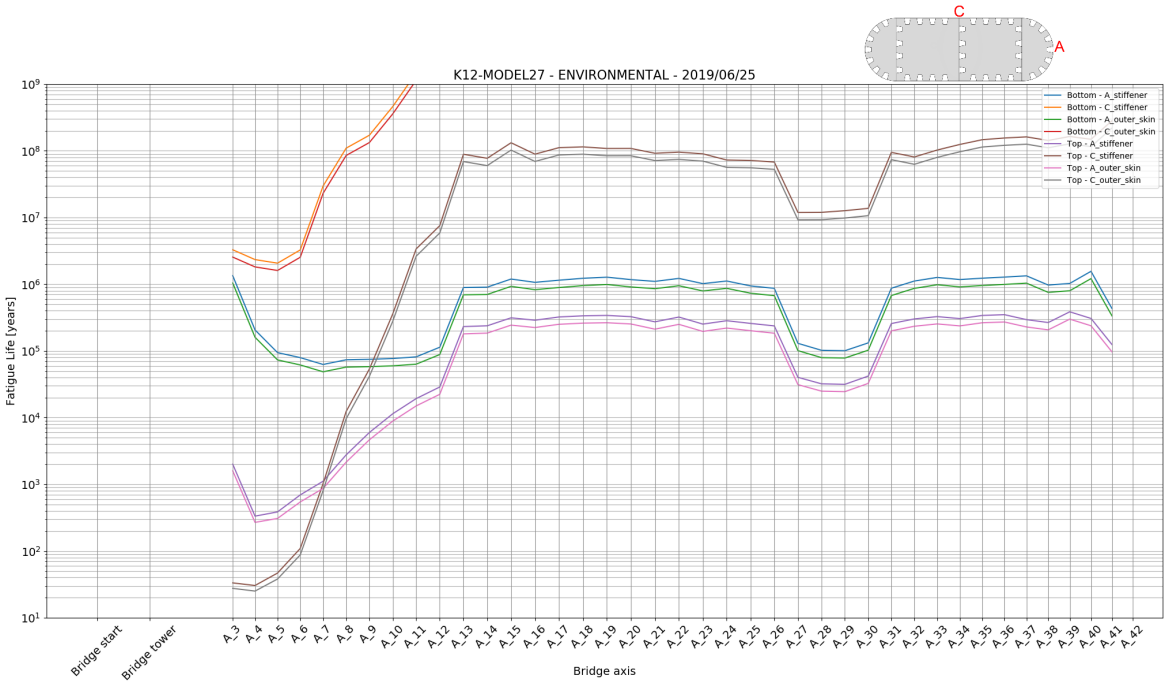


Figure 18: Column fatigue life plot from environmental condition

2 STRESS TRANSFER FACTORS AND SECTION DATA

2.1 Stress transfer factors

2.1.1 Bridge girder

Stress transfer factors

> *Table 1: Bridge girder stress transfer factors (myy weak axis, mzz strong axis, fxx axial)*

Point	A	B	C	D	E	F	G	H	I
BCS1									
myy	-0,5859	-0,4801	-0,4385	0,1964	0,7038	0,7217	0,7038	0,1725	-0,4016
mzz	0,0148	0,0826	0,1231	0,1257	0,0771	0,0000	-0,0738	-0,1251	-0,1260
fxx	0,6799	0,6799	0,6799	0,6799	0,6799	0,6799	0,6799	0,6799	0,6799
BCS2									
myy	-0,4967	-0,4070	-0,3718	0,1665	0,5967	0,6119	0,5967	0,1462	-0,3405
mzz	0,0129	0,0719	0,1072	0,1095	0,0671	0,0000	-0,0643	-0,1089	-0,1097
fxx	0,5738	0,5738	0,5738	0,5738	0,5738	0,5738	0,5738	0,5738	0,5738
BCS1 at Column									
myy	-0,4499	-0,3770	-0,3478	0,0849	0,4432	0,4545	0,4432	0,0745	-0,3223
mzz	0,0128	0,0713	0,1062	0,1085	0,0665	0,0000	-0,0637	-0,1079	-0,1087
fxx	0,4151	0,4151	0,4151	0,4151	0,4151	0,4151	0,4151	0,4151	0,4151
BCS2 at Column									
myy	-0,3878	-0,3232	-0,2974	0,0875	0,4032	0,4135	0,4032	0,0768	-0,2748
mzz	0,0114	0,0637	0,0950	0,0970	0,0595	0,0000	-0,0570	-0,0965	-0,0972
fxx	0,3762	0,3762	0,3762	0,3762	0,3762	0,3762	0,3762	0,3762	0,3762
P1									
myy	-0,5496	-0,4523	-0,4139	0,1612	0,6378	0,6541	0,6378	0,1415	-0,3800
mzz	0,0126	0,0780	0,1163	0,1188	0,0777	0,0000	-0,0746	-0,1183	-0,1192
fxx	0,6300	0,6300	0,6300	0,6300	0,6300	0,6300	0,6300	0,6300	0,6300
P2									
myy	-0,4920	-0,4082	-0,3749	0,1086	0,5330	0,5466	0,5330	0,0954	-0,3456

mzz	0,0088	0,0702	0,1048	0,1070	0,0788	0,0000	-0,0759	-0,1069	-0,1077
fxx	0,5495	0,5495	0,5495	0,5495	0,5495	0,5495	0,5495	0,5495	0,5495
P3									
myy	-0,4457	-0,3721	-0,3427	0,0687	0,4560	0,4677	0,4560	0,0603	-0,3169
mzz	0,0057	0,0639	0,0953	0,0974	0,0796	0,0000	-0,0769	-0,0974	-0,0982
fxx	0,4872	0,4872	0,4872	0,4872	0,4872	0,4872	0,4872	0,4872	0,4872
P4									
myy	-0,4116	-0,3461	-0,3197	0,0373	0,3932	0,4033	0,3932	0,0328	-0,2967
mzz	0,0032	0,0585	0,0874	0,0892	0,0803	0,0000	-0,0778	-0,0895	-0,0902
fxx	0,4376	0,4376	0,4376	0,4376	0,4376	0,4376	0,4376	0,4376	0,4376
P5									
myy	-0,3842	-0,3251	-0,3011	0,0120	0,3426	0,3514	0,3426	0,0106	-0,2803
mzz	0,0010	0,0539	0,0806	0,0823	0,0810	0,0000	-0,0786	-0,0828	-0,0835
fxx	0,3972	0,3972	0,3972	0,3972	0,3972	0,3972	0,3972	0,3972	0,3972
HF6									
myy	-0,3724	-0,3161	-0,2931	0,0000	0,3209	0,3290	0,3209	0,0000	-0,2733
mzz	0,0000	0,0519	0,0776	0,0793	0,0813	0,0000	-0,0789	-0,0799	-0,0805
fxx	0,3797	0,3797	0,3797	0,3797	0,3797	0,3797	0,3797	0,3797	0,3797

SCFs from Abaqus ref. ch. 3.3.1

> *Table 2: SCFs as explained in ch 3.3.1 in main report.*

Point	A	B	C	D	E	F	G	H	I
Myy	0,973*	1,010	0,925*	1,159	0,961*	1,026	0,936*	1,018	0,991*
mzz	0,929*	1,010	1,025	1,047	1,073	1,000	1,029	1,041	1,049

* All factors <1,0 are set to a factor equal 1,0 as a conservative measure. All factors are included in the values given in Table 1 for bending moments.

SCFs for different section thicknesses and misalignment

> *Table 3: SCFs for butt welds between plates of same thickness with misalignment 2 mm and different thickness and misalignment 1,5 mm. Ref. ch. 2.4.3 in main report.*

Plate 1		Plate 2	SCF same thickness, plate 1 – plate 1	SCF different thickness plate 1 - plate 2
		misalignment 2 mm	misalignment 1,5 mm	
10	11	1,30		1,28
12	13	1,20		1,19
14	15	1,13		1,12
16	17	1,08		1,07

It is assumed that plate thicknesses between section transitions are stepped with 1 mm for smooth section transition to reduce SCFs.

2.1.2 Column

> *Table 4: Column stress transfer factors*

Stiffener/ Outer skin	Unit(Nxx) [MPa/N]	Unit(Myy) [MPa/Nm]	Unit(Mzz) [MPa/Nm]
A	0,725	0	-0,298
C	0,725	-0,516	0

2.2 Section data

> *Table 5: Section data bridge girder*

Section/parameter	Value	Unit	Section/parameter	Value	Unit
P1 (north end)			P5		
Iy	2,9475	m^4	Iy	4,8155	m^4
Iz	121,5434	m^4	Iz	174,4826	m^4
A	1,58721	m^2	A	2,51769	m^2
P2 (north end)			BCS1 (main sect.)		
Iy	3,4145	m^4	Iy	2,714	m^4
Iz	134,7782	m^4	Iz	114,926	m^4
A	1,81983	m^2	A	1,4709	m^2
P3 (north end)			BCS2 (sect. at slope at cable stayed bridge)		
Iy	3,8815	m^4	Iy	3,201	m^4
Iz	148,013	m^4	Iz	132,013	m^4
A	2,05245	m^2	A	1,7429	m^2
P4 (north end)			HF6 (south end)		
Iy	4,3485	m^4	Iy	5,049	m^4
Iz	161,2478	m^4	Iz	181,1	m^4
A	2,28507	m^2	A	2,634	m^2
BCS1 at Column			BCS2 at Column		
Iy	4,3485	m^4	Iy	4,425	m^4
Iz	161,2478	m^4	Iz	148,959	m^4
A	2,28507	m^2	A	2,658	m^2

"BCS1 at Column" and "BCS2 at Column" are reinforced sections at columns with higher 2nd moment of area than the regular cross sections BCS1 and BCS2.

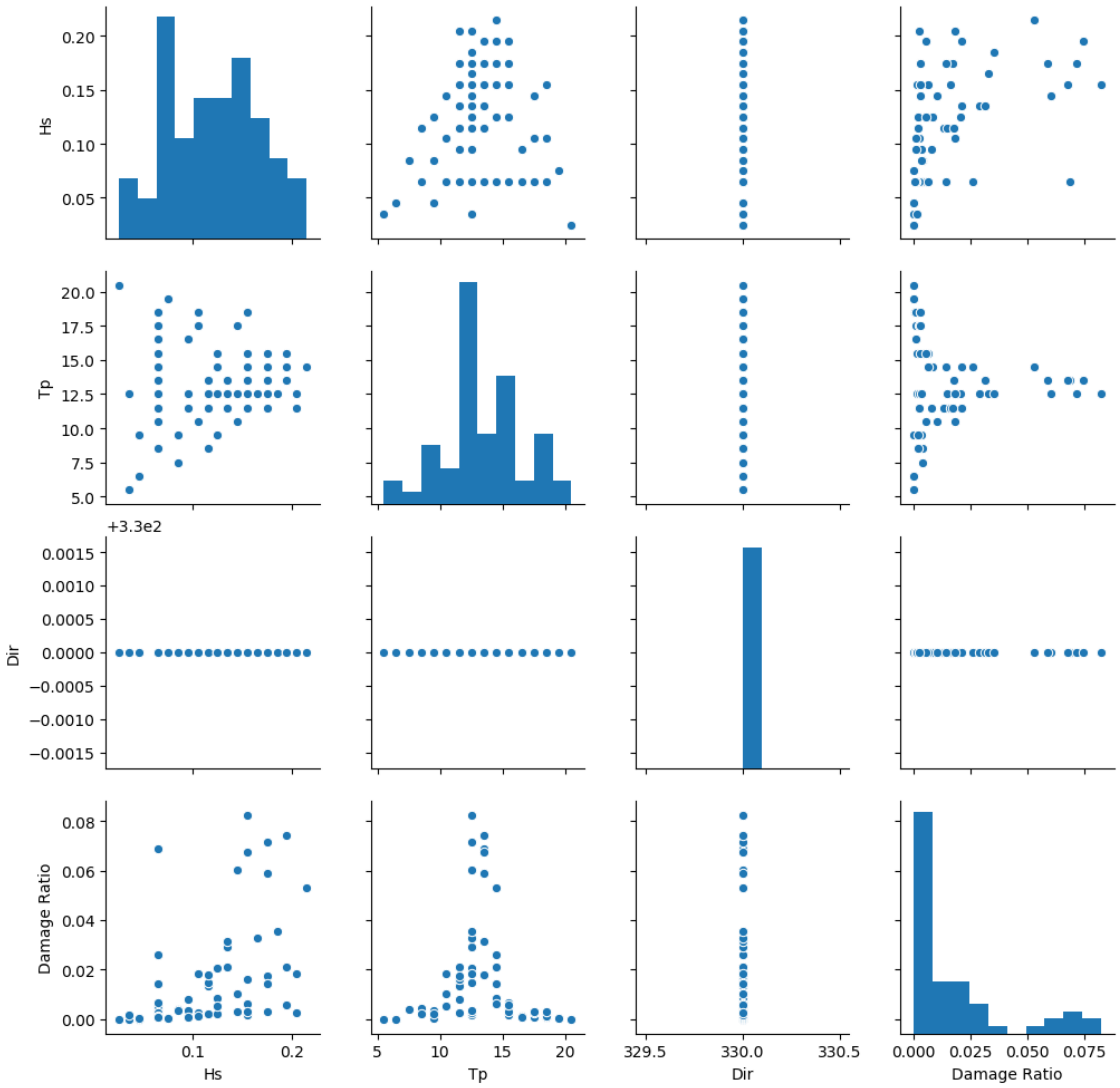
> *Table 6: Section data columns*

Section/parameter	Value	Unit
Column 4 m x 12 m		
Iy (strong axis)	20,1	m^4
Iz (weak axis)	3,9	m^4
A	1,38	m^2

3 PAIRPLOTS

In this section pairplots describing the environmental cases contribution most to the fatigue damage are shown. Each dot in the plots represent an environmental case. The plot is symmetric on the off diagonals and the distribution histograms for the environmental parameters and the fatigue damage are given on the diagonals.

The chosen positions for the presented pairplots are based on the positions dominating the fatigue life. For wind and swell one position is taken, but for wind sea two positions are chosen, since different wind sea directions dominate the fatigue life differently towards the two bridge ends.



> *Figure 19: Swell pairplot at axis A_20 for bridge girder point I*

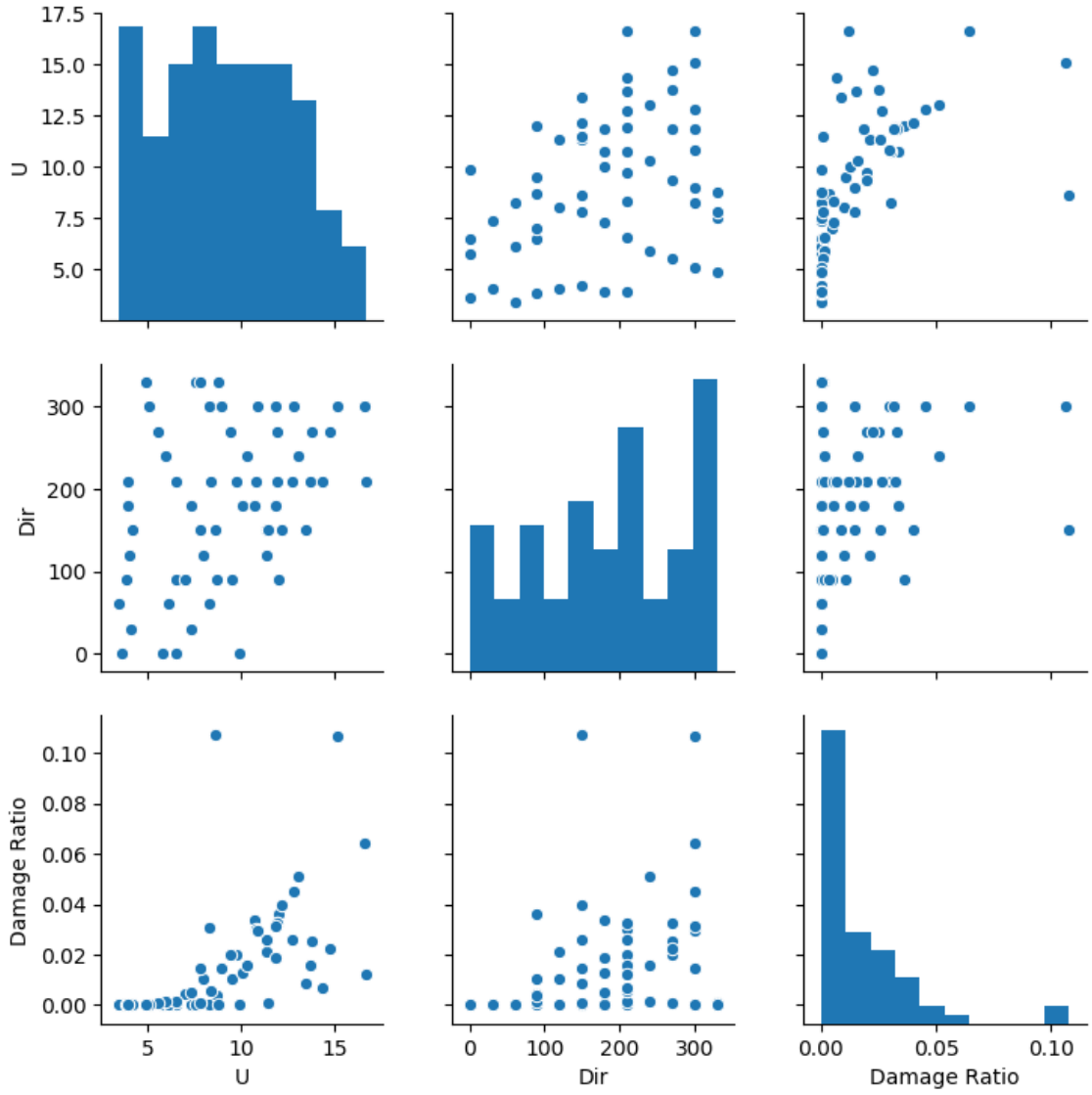
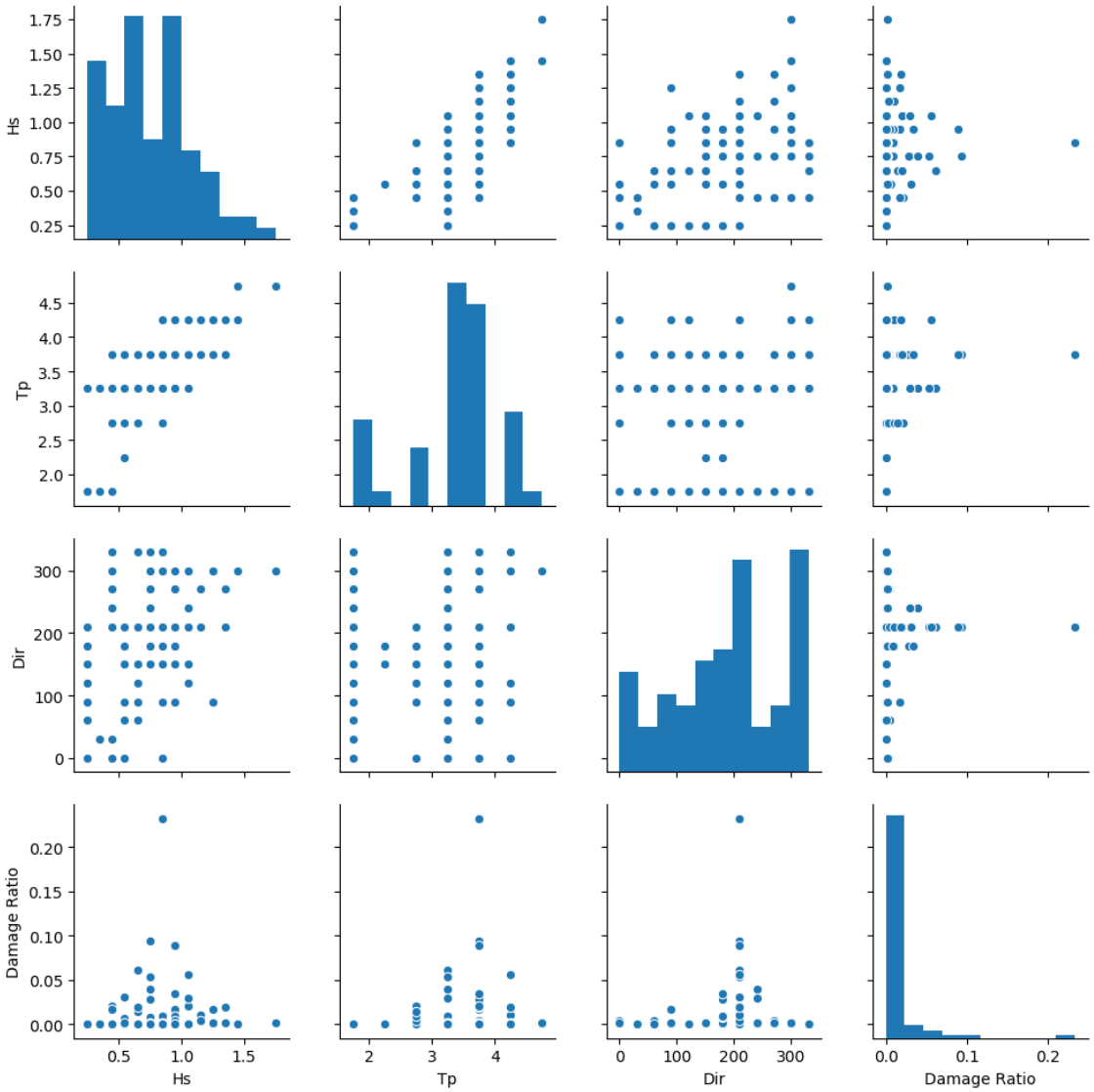


Figure 20: Wind pairplot at axis A_20 for bridge girder point I



> *Figure 21: Wind sea pairplot at axis A_4 for bridge girder point G*

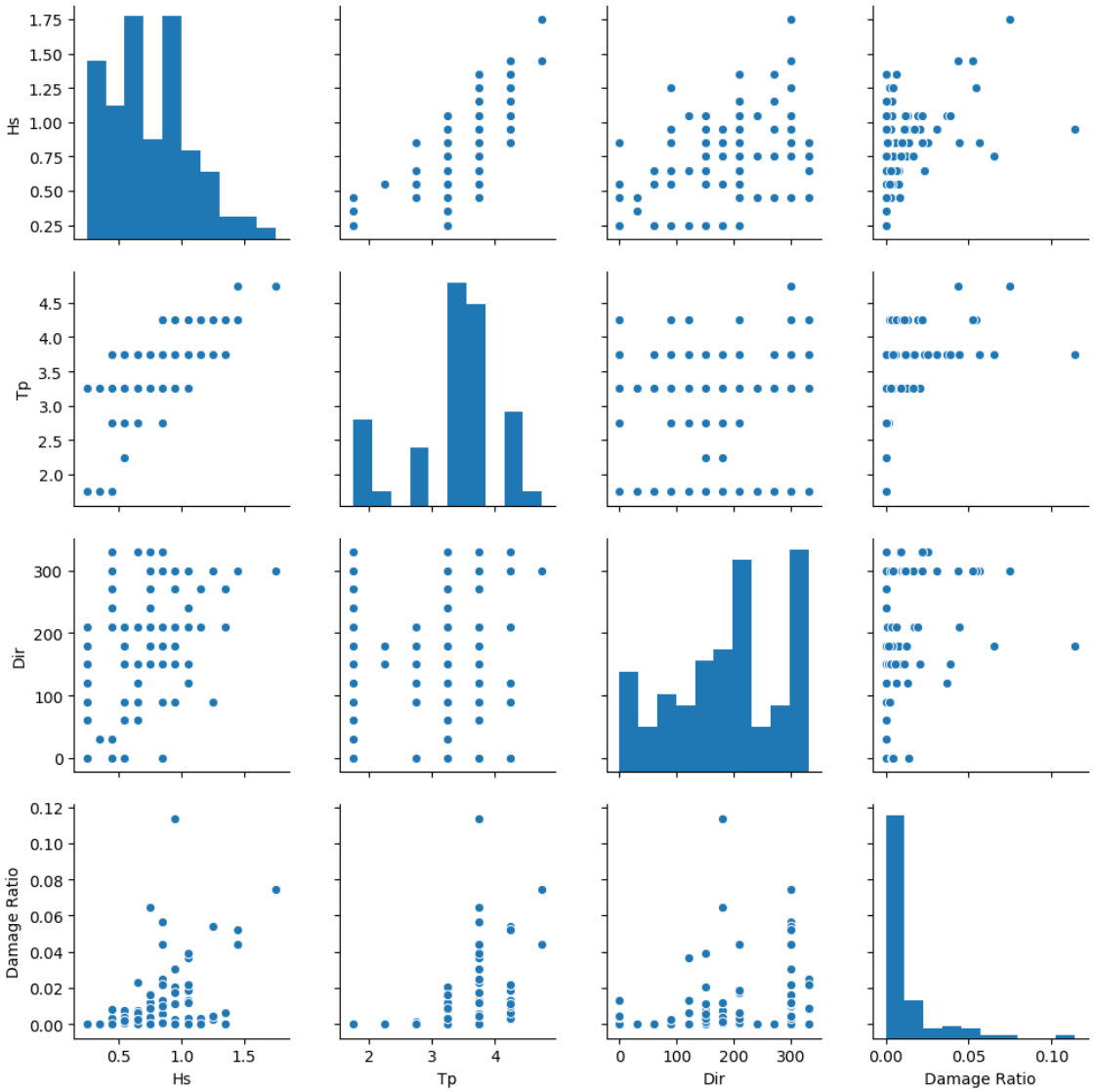


Figure 22 Wind sea pairplot at axis A_41 fo