

Wind tunnel study of global wind loads on a swing bridge

Okke Bronkhorst | Chris Geurts

Jurriaan Akhnoukh | Marcel van Uffelen



August 27-31, 2023
FLORENCE - ITALY

16th International
Conference on
Wind Engineering



Rijkswaterstaat
Ministry of Infrastructure
and Water Management

TNO innovation
for life

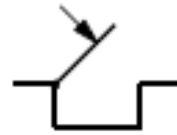
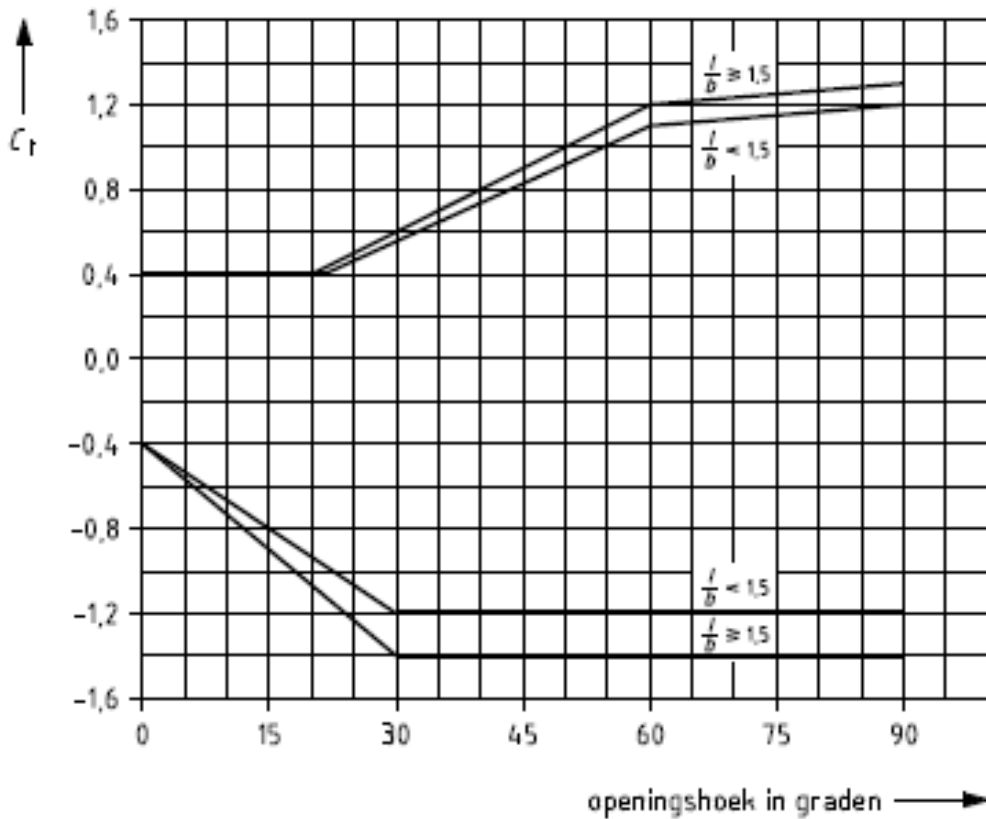
PEUTZ

Background

- Until 2040 ~175 movable bridges reach end of design life
- Need for reassessment of the structural safety



Background: Dutch design code NEN 6786-1



NEN 6786-1+C1 – Rules for the design of movable parts of civil structures – Part 1: Movable bridges, Delft, 2021.

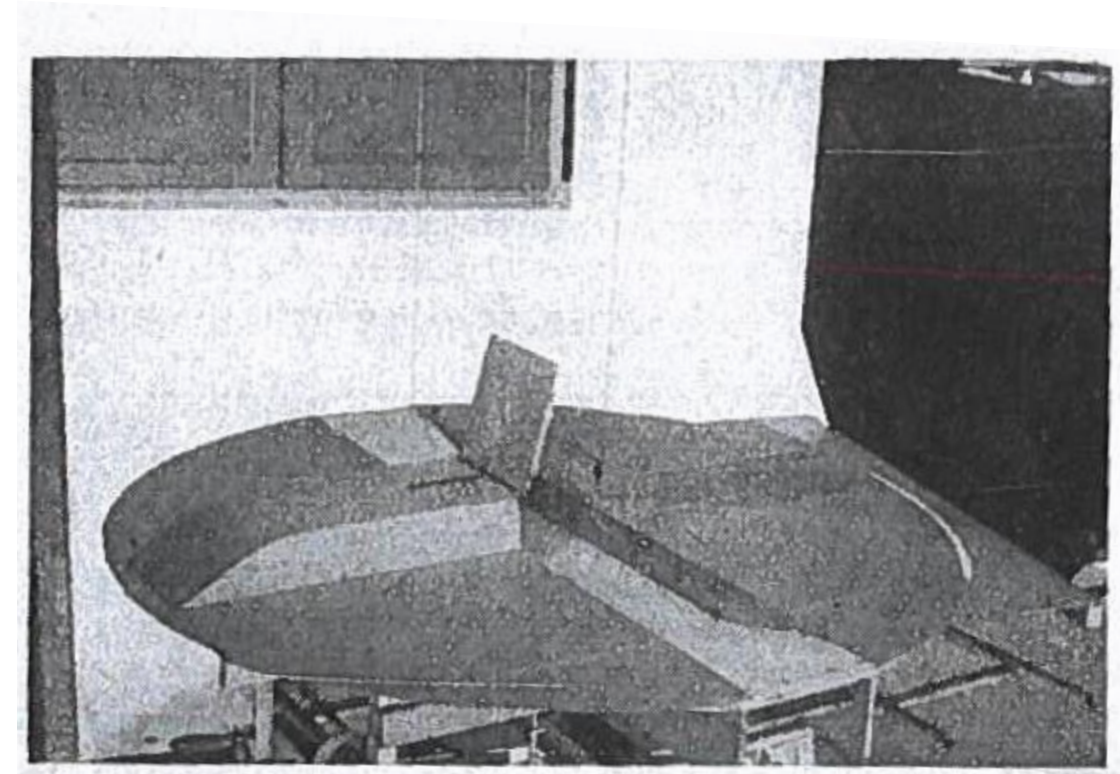
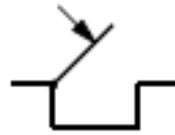
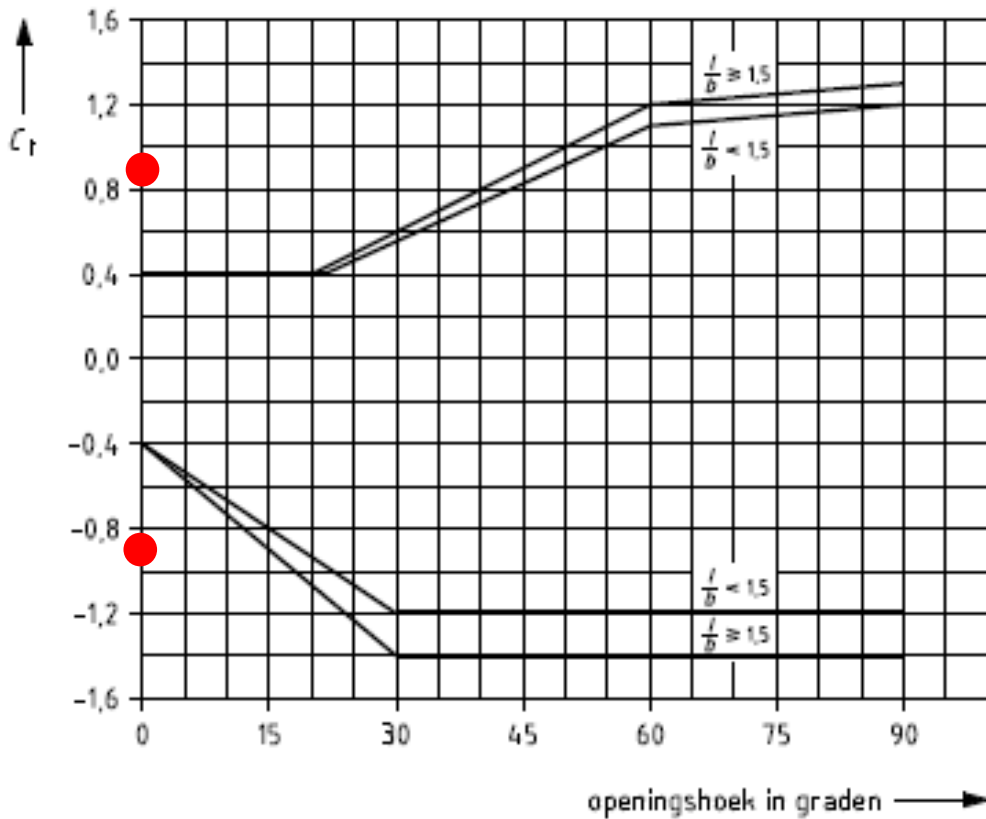


Fig. 4. Brugmodel.

Allaart, P.J., Een onderzoek naar de winddruk op beweegbare bruggen met horizontale draaiingsas, De Ingenieur, 1949.

Background: Comparison EN 1991-1-4

• EN 1991-1-4



NEN 6786-1+C1 – Rules for the design of movable parts of civil structures – Part 1: Movable bridges, Delft, 2021.

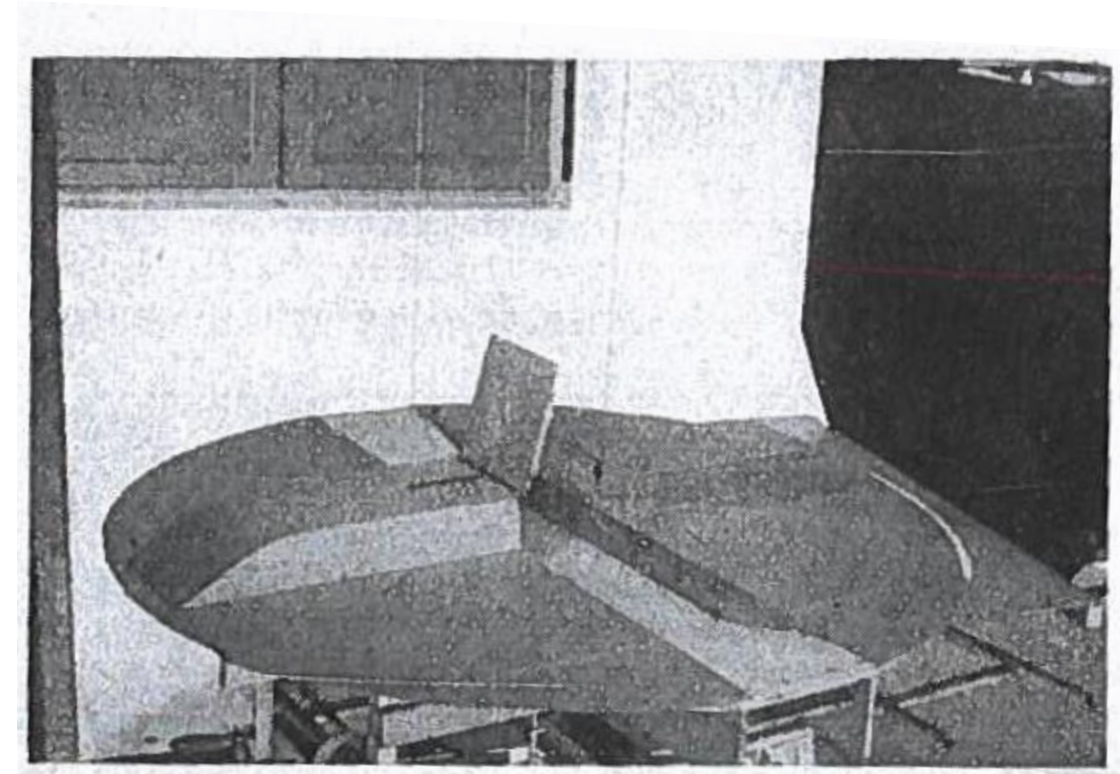
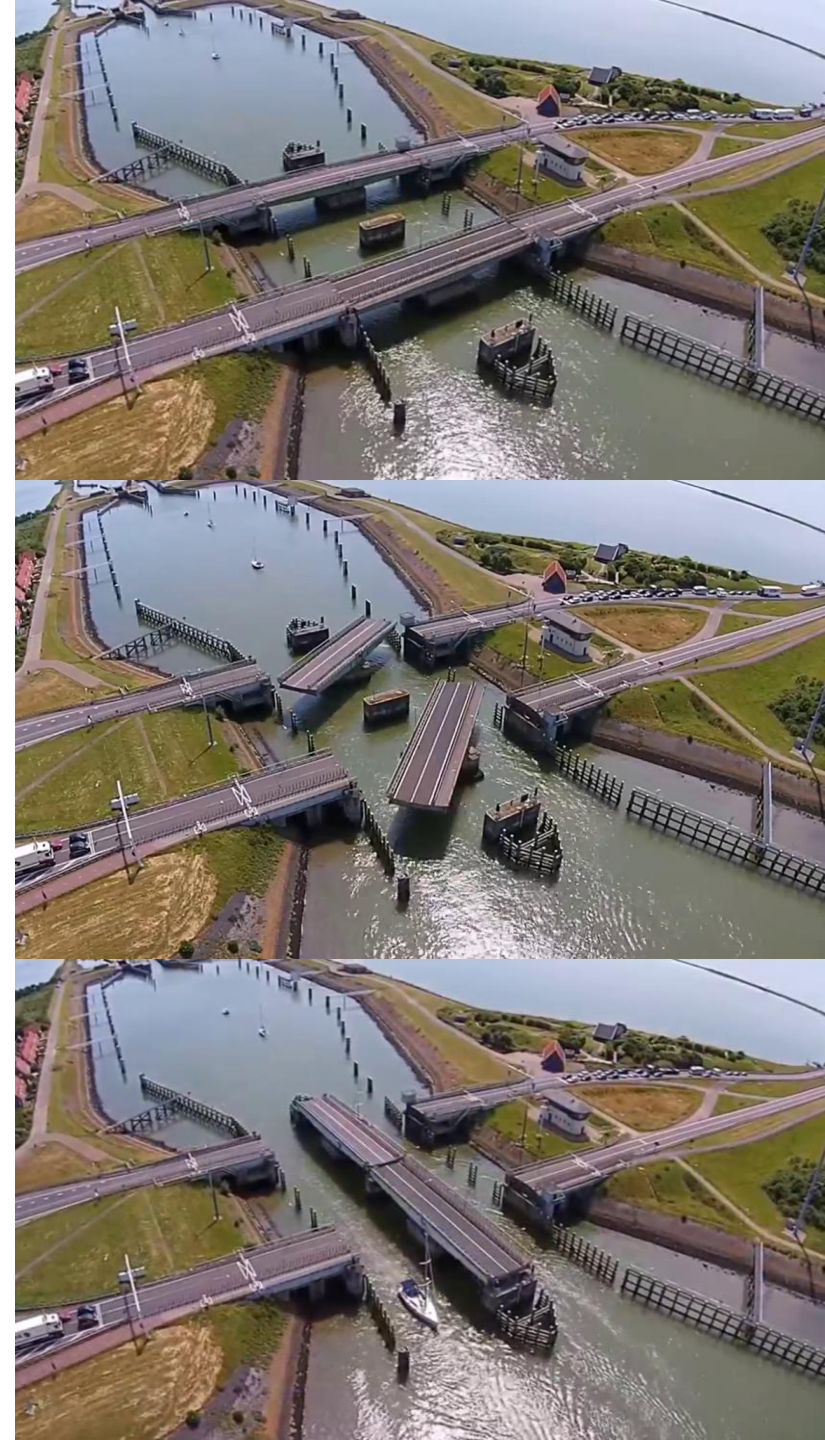


Fig. 4. Brugmodel.

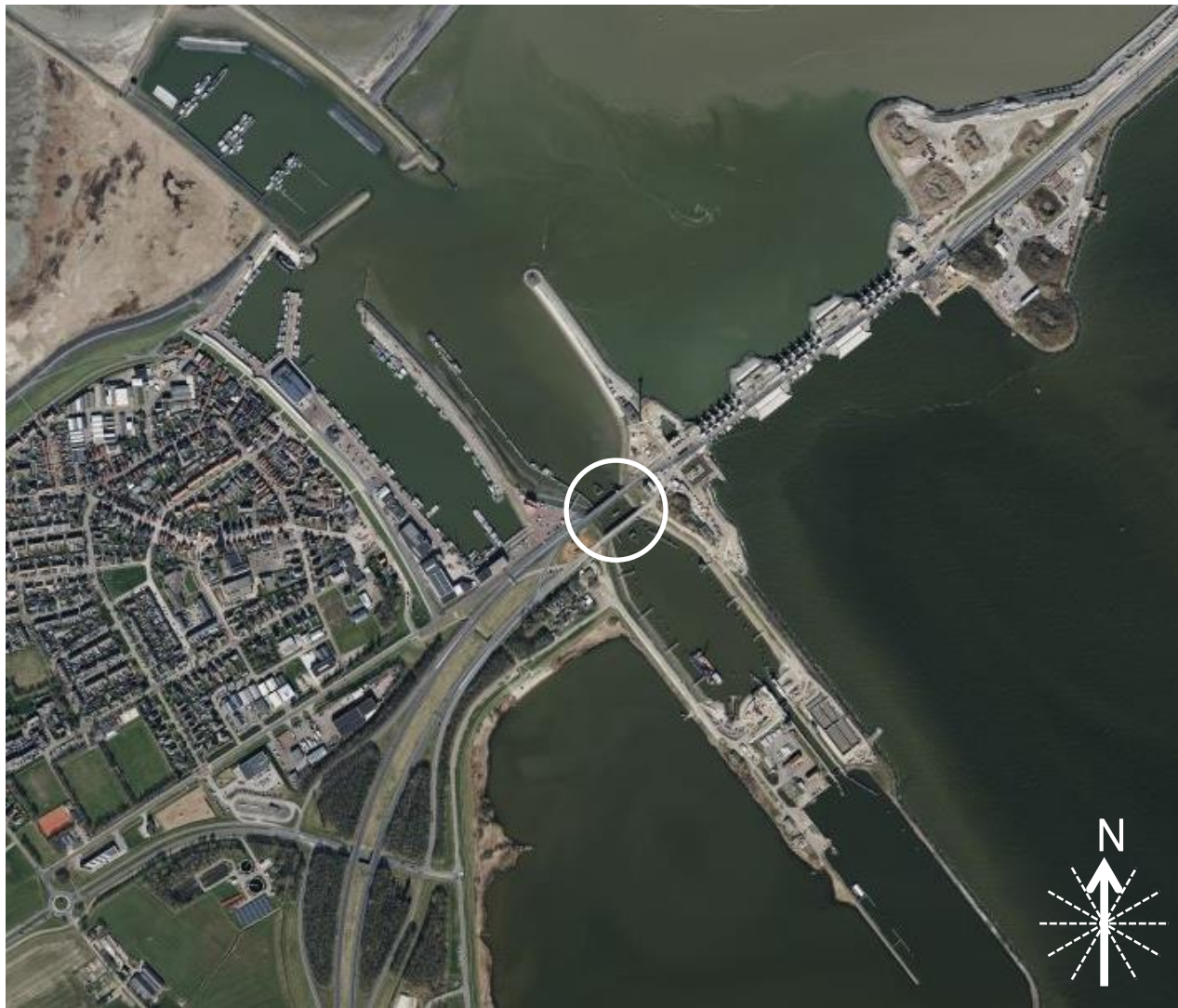
Allaart, P.J., Een onderzoek naar de winddruk op beweegbare bruggen met horizontale draaiingsas, De Ingenieur, 1949.

Swing bridges renovation

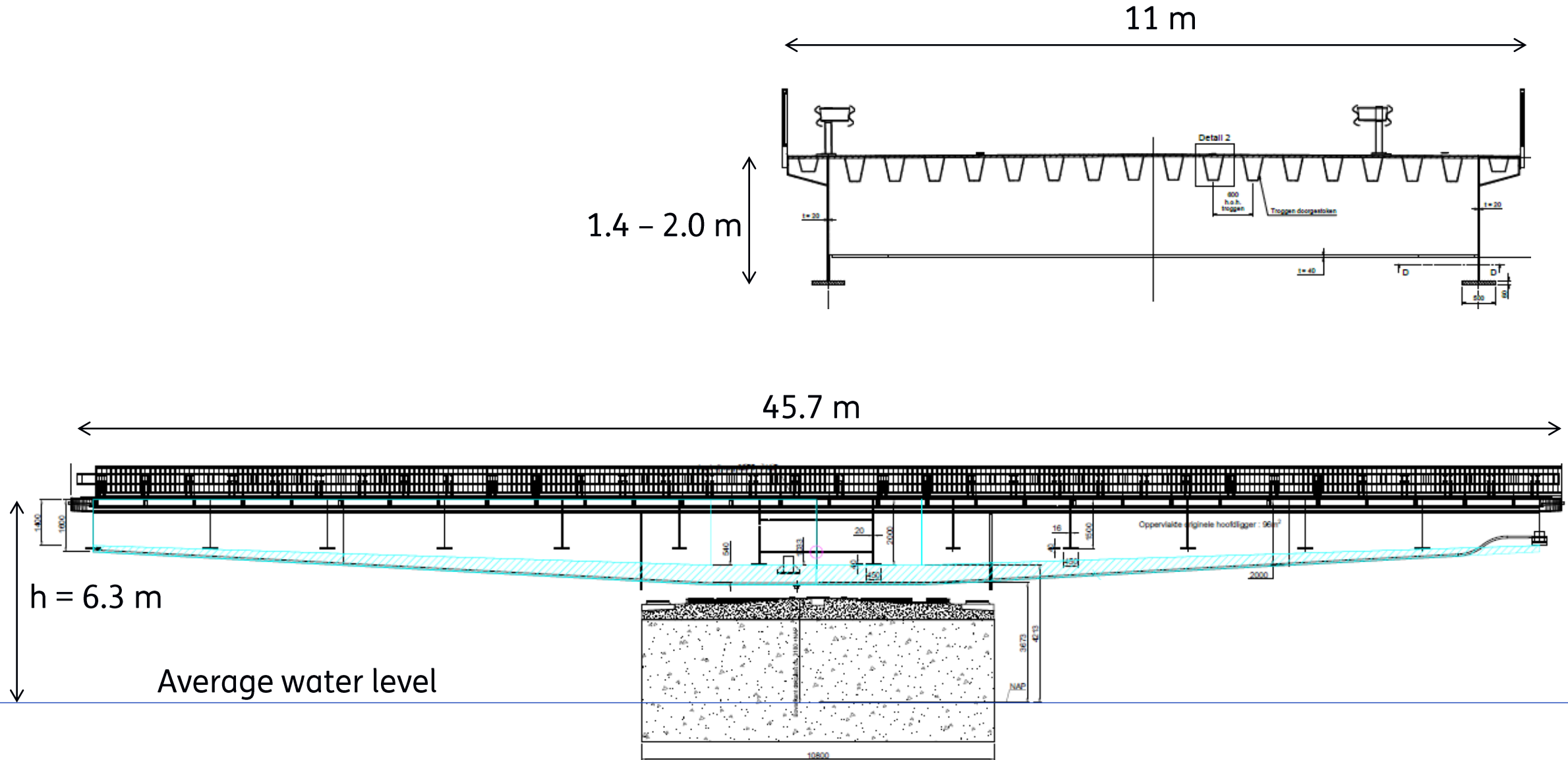
- Reassessment rotation machinery
 - Torsional wind moment M_z
 - Wind tunnel study global wind loads
- Comparison with code provisions



Surroundings

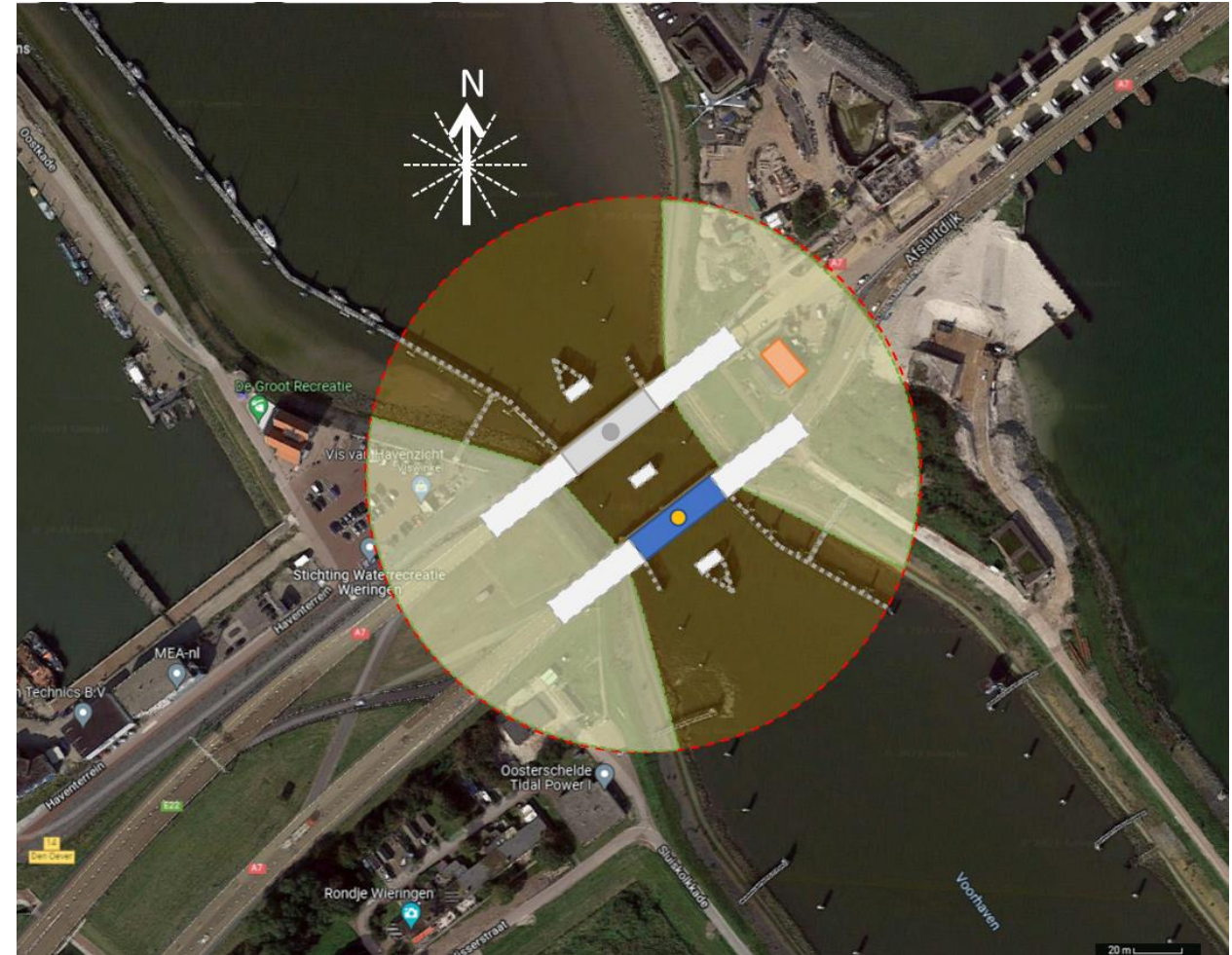


Bridge dimensions



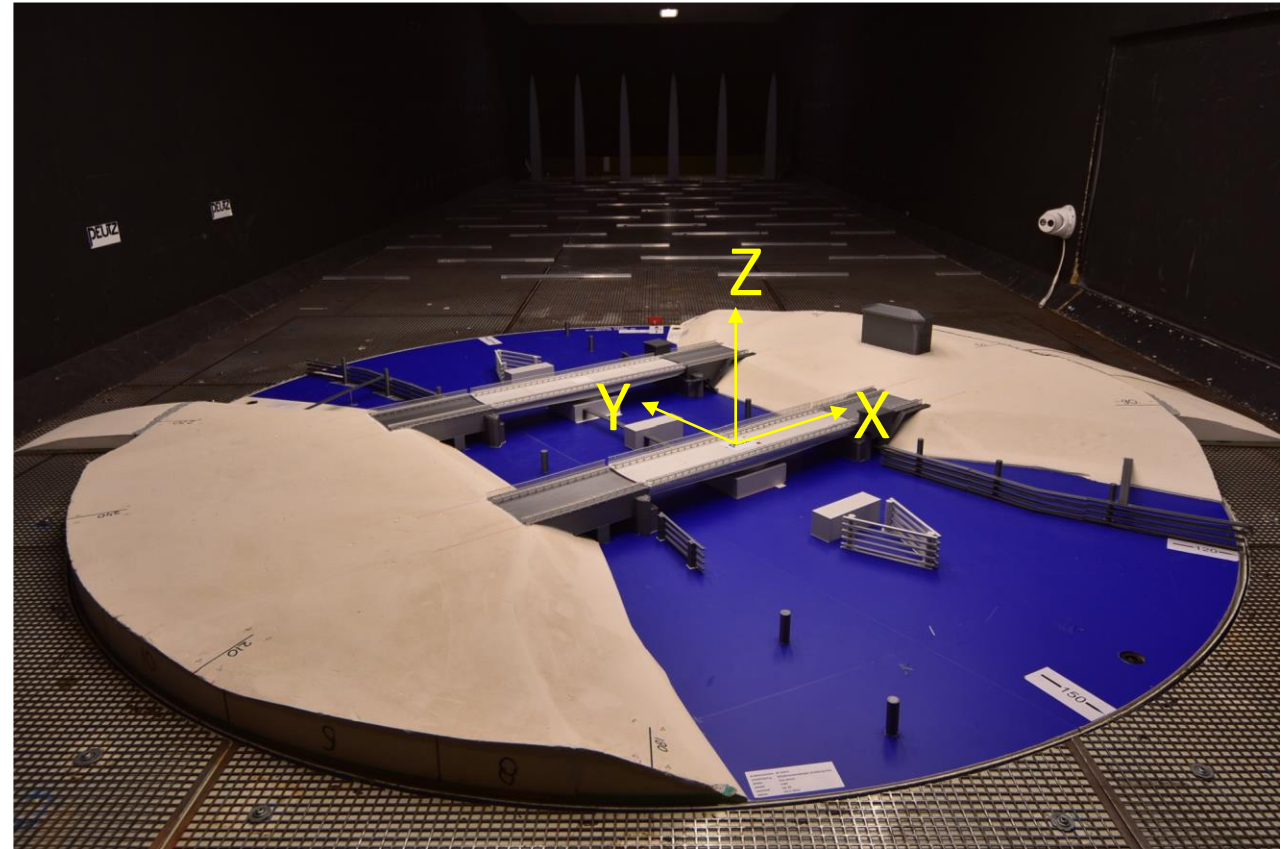
Wind tunnel model

- Geometric scale 1:80

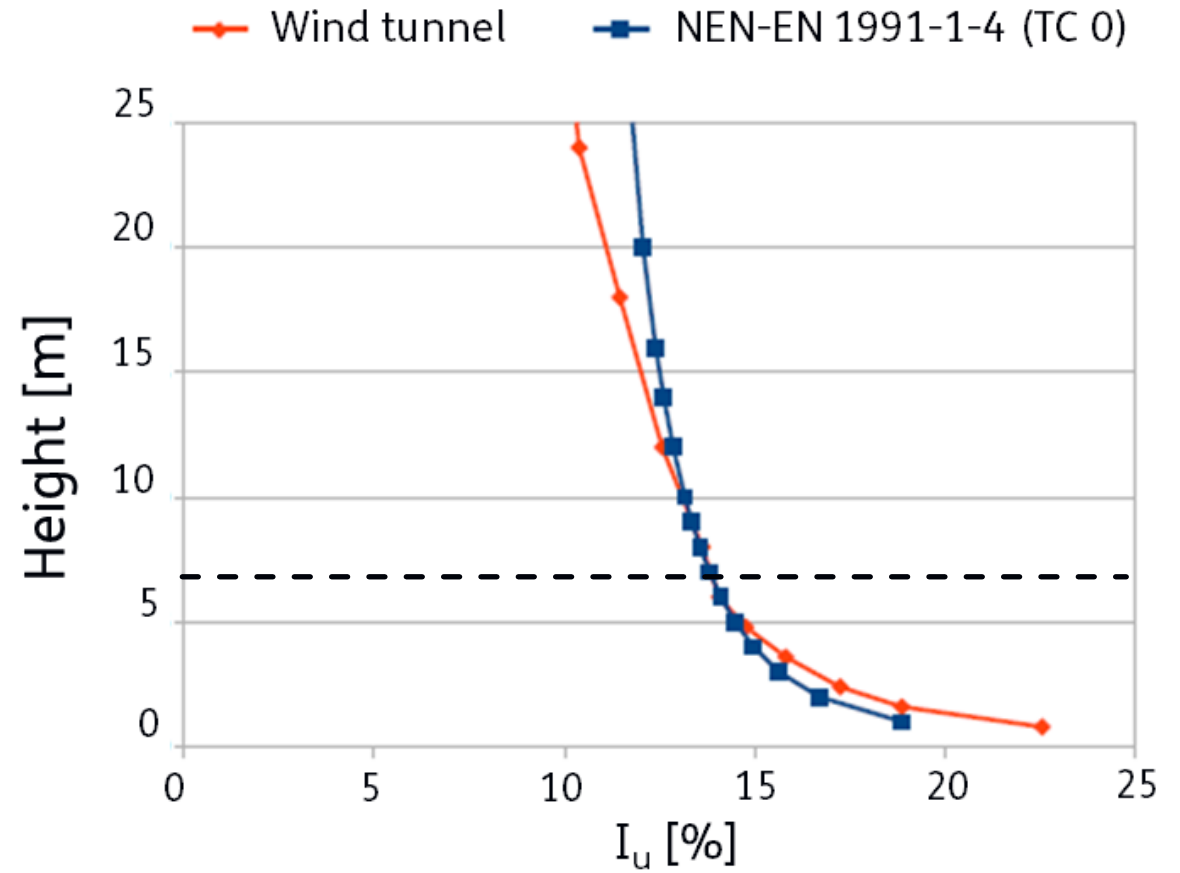
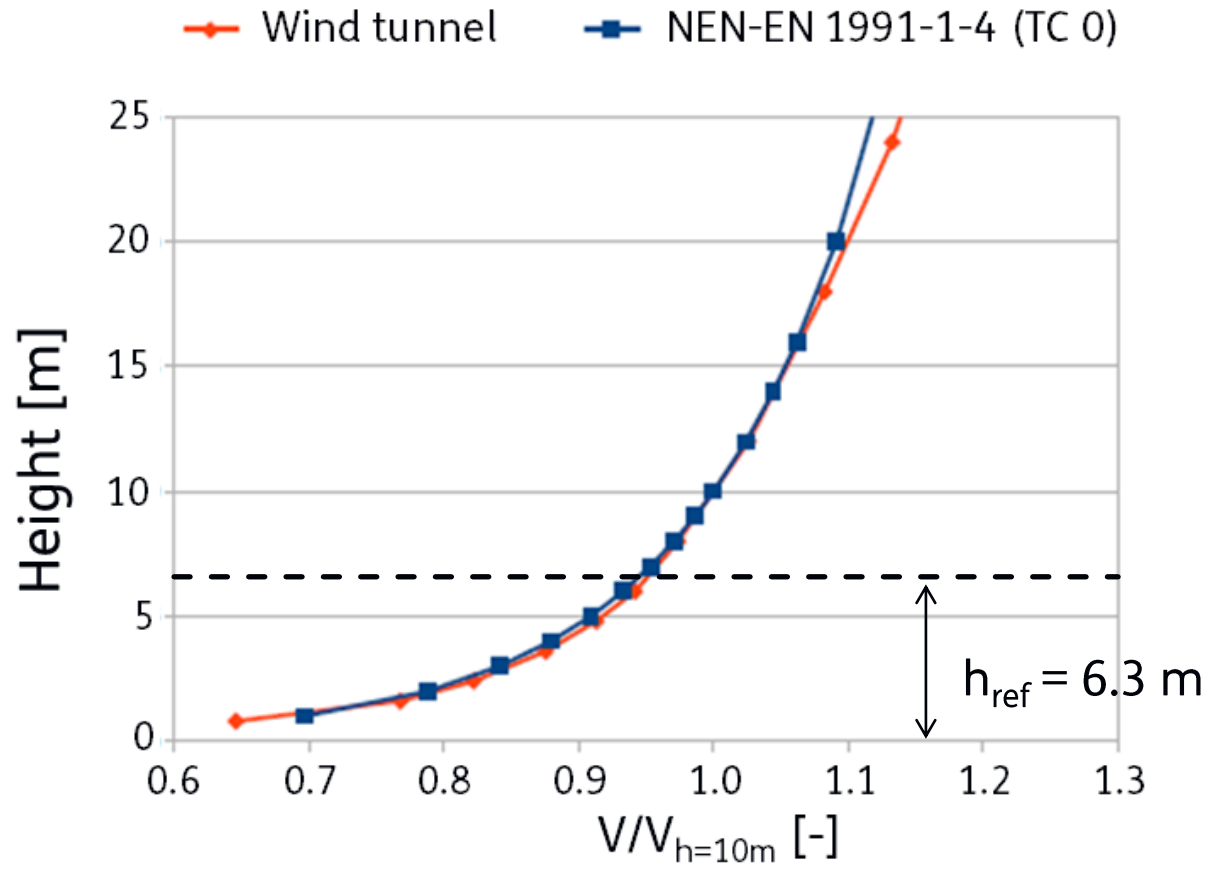


Wind tunnel model

- Geometric scale 1:80
- 3D printed bridge models
- HFFB measurements

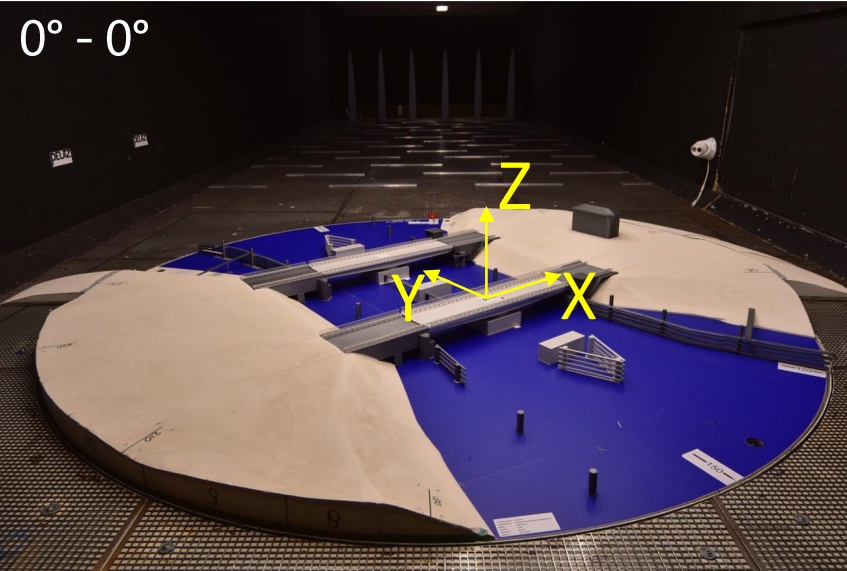


Boundary layer

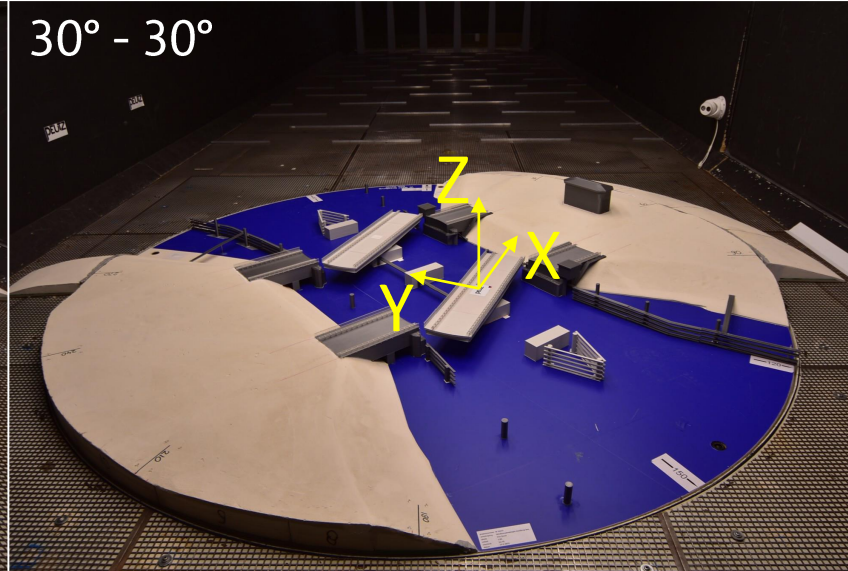


Configurations

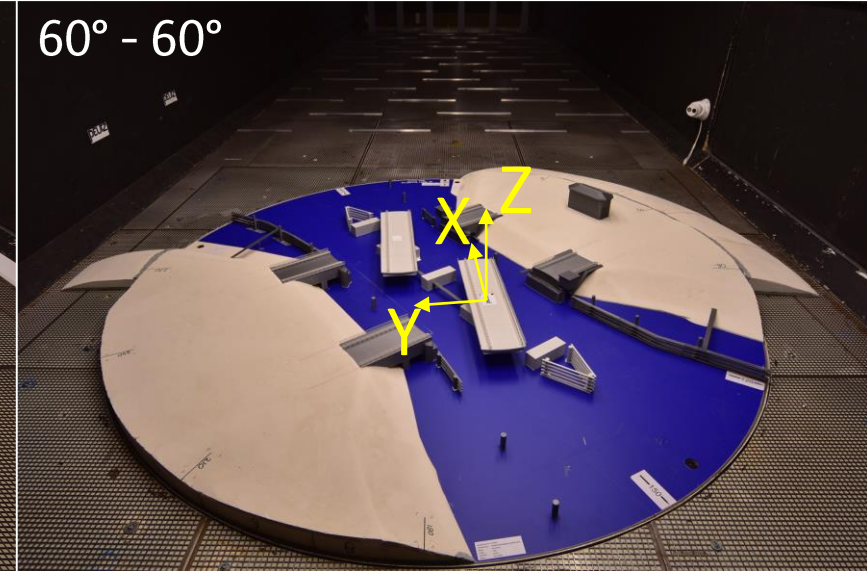
0° - 0°



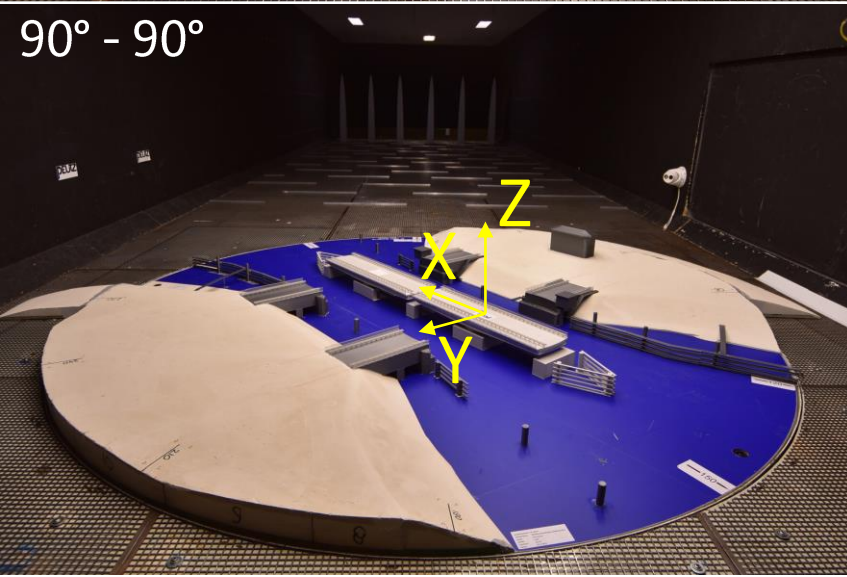
30° - 30°



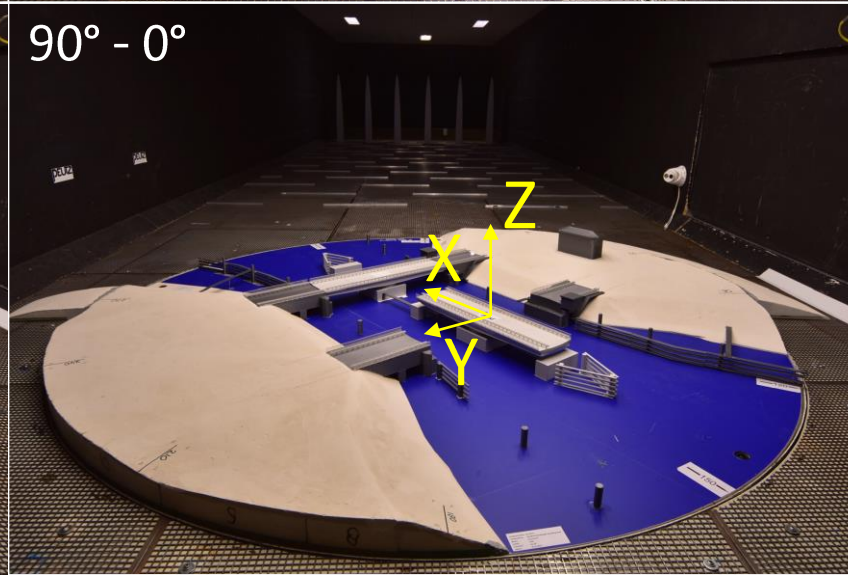
60° - 60°



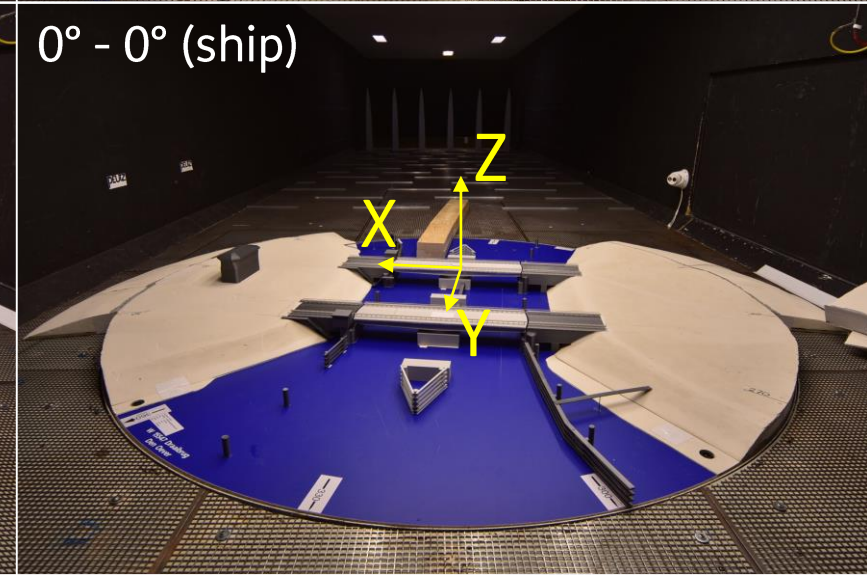
90° - 90°



90° - 0°

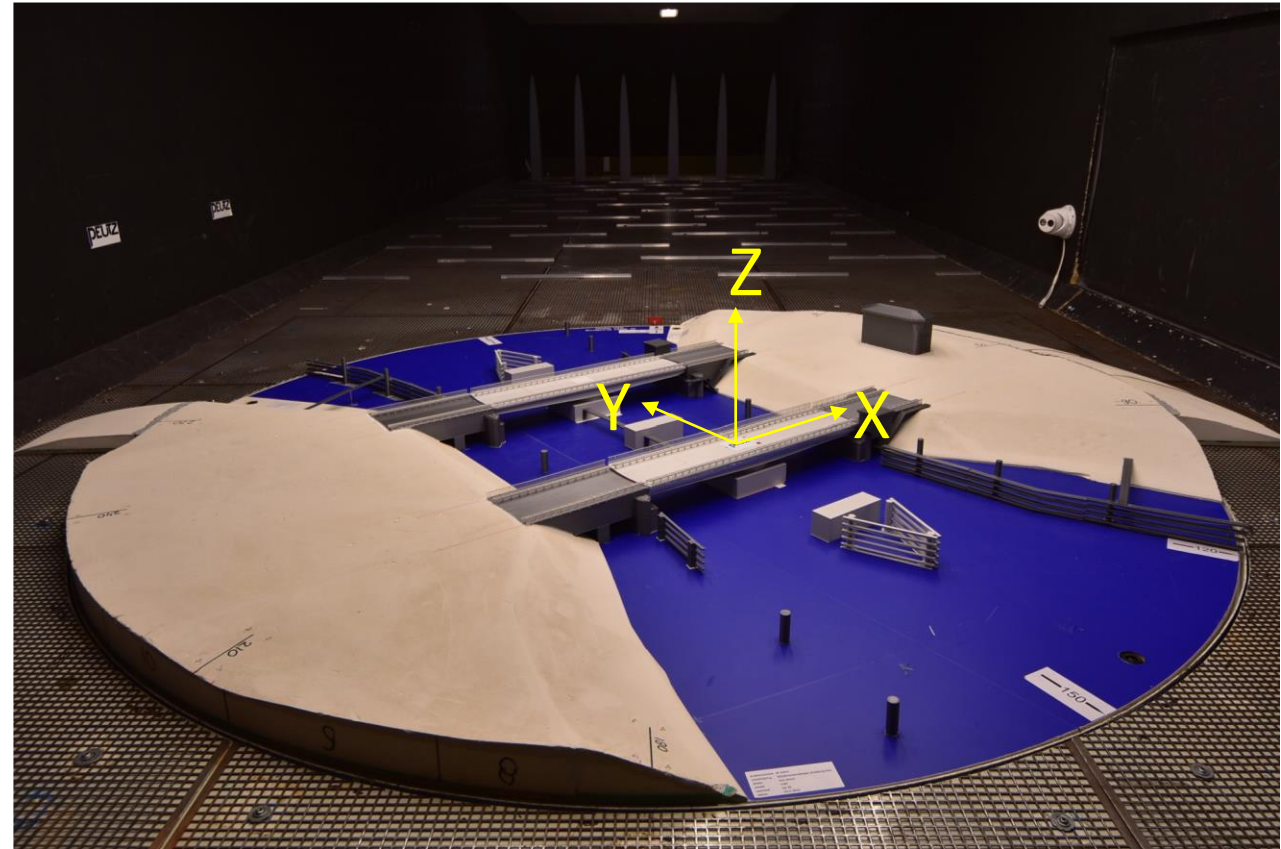


0° - 0° (ship)

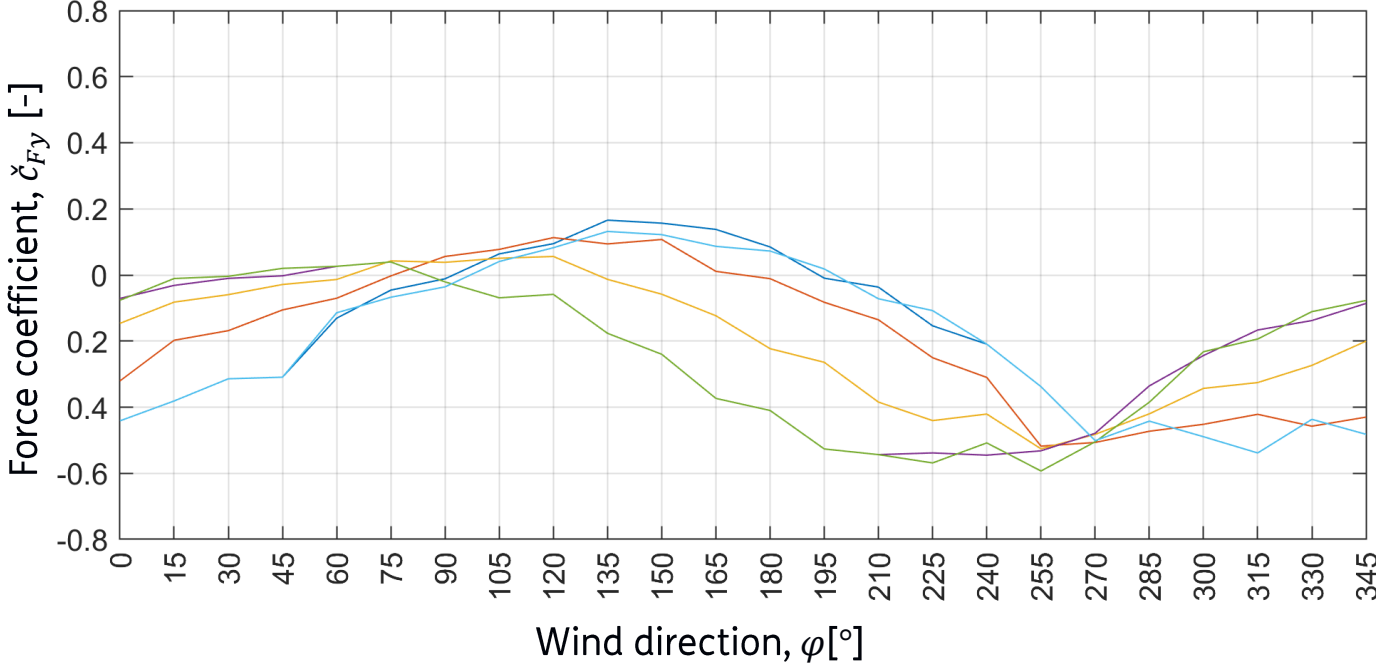
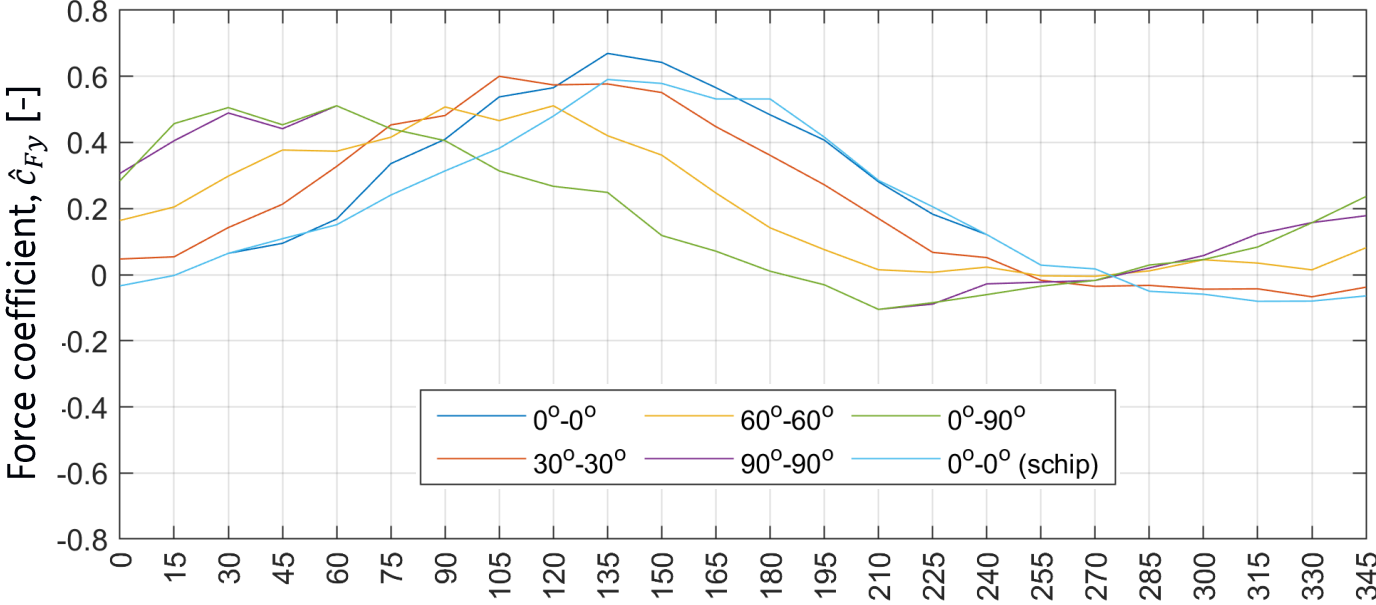
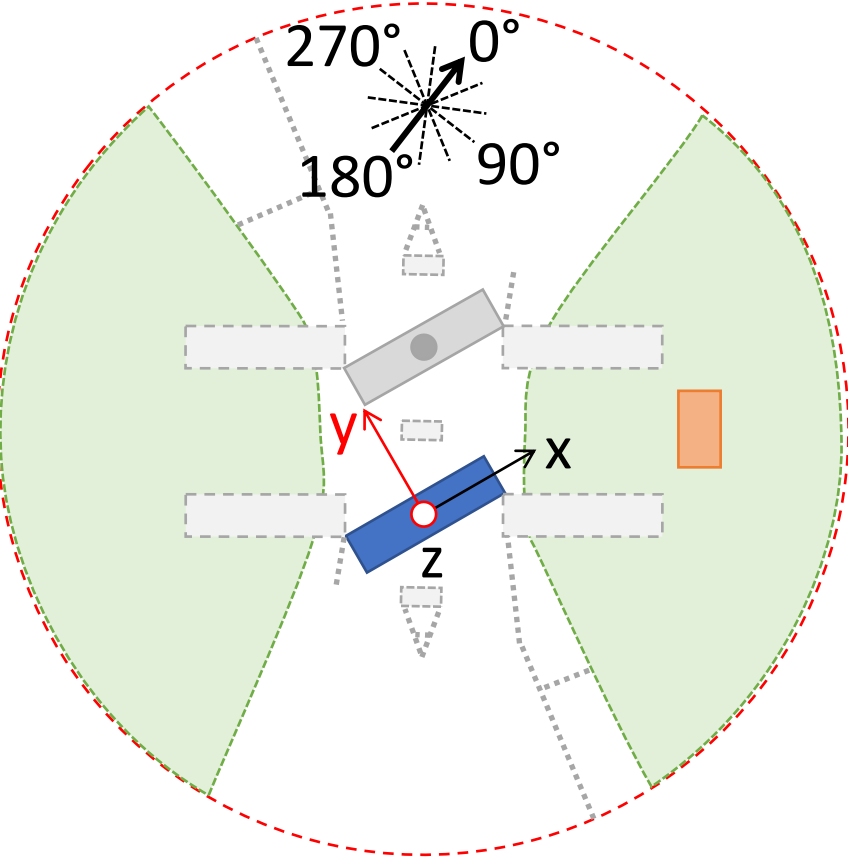


Data acquisition and analysis

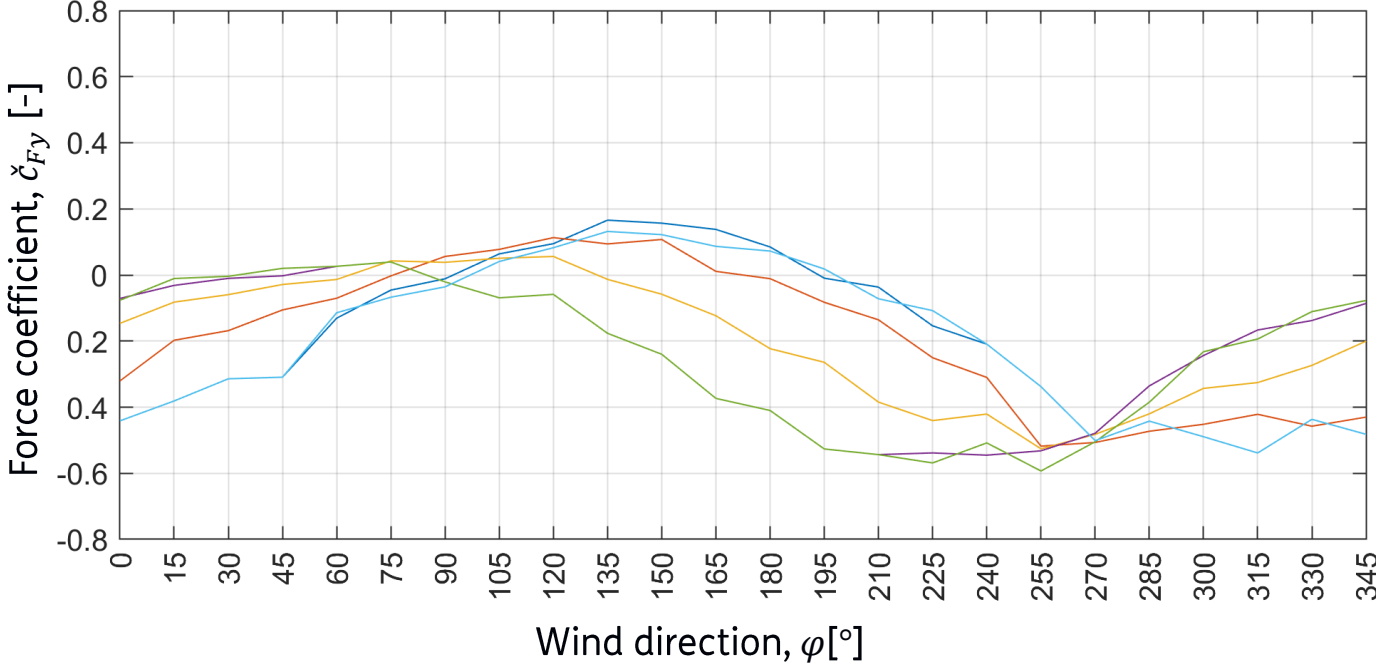
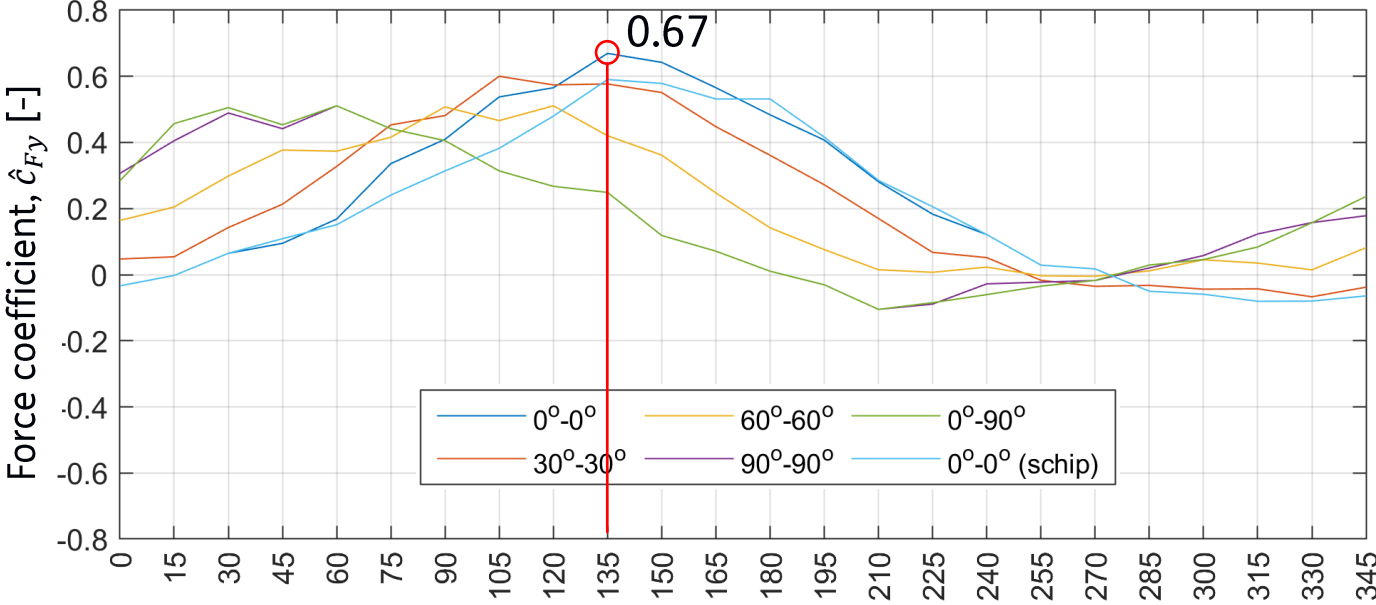
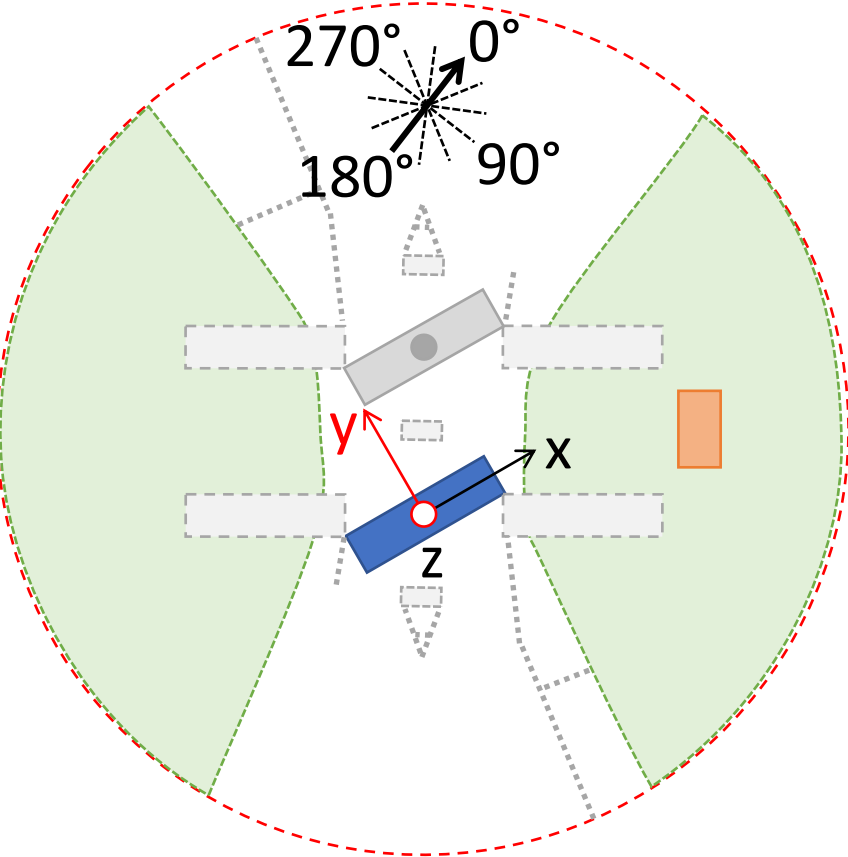
- Acquisition
 - 24 wind directions
 - Sampling rate 400 Hz
 - Record length 120 s
- Analysis
 - Extreme value analysis (CUR, 2005)
 - Code compliant coefficients



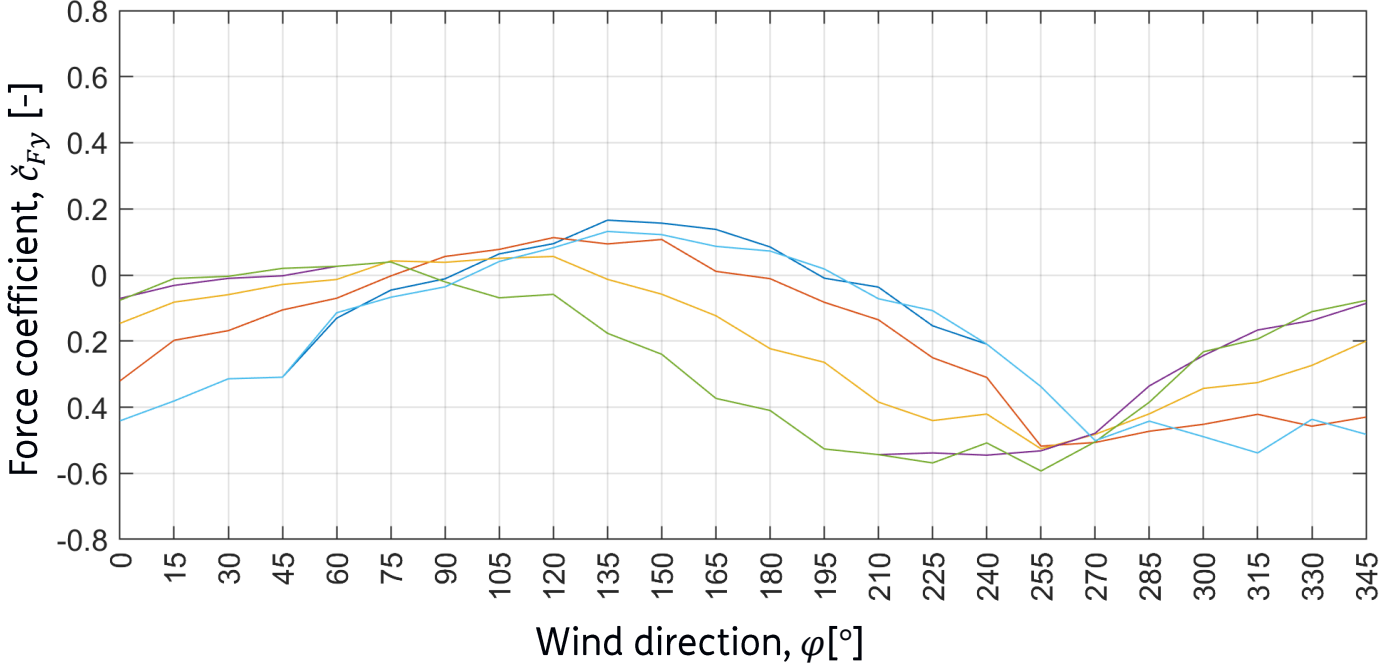
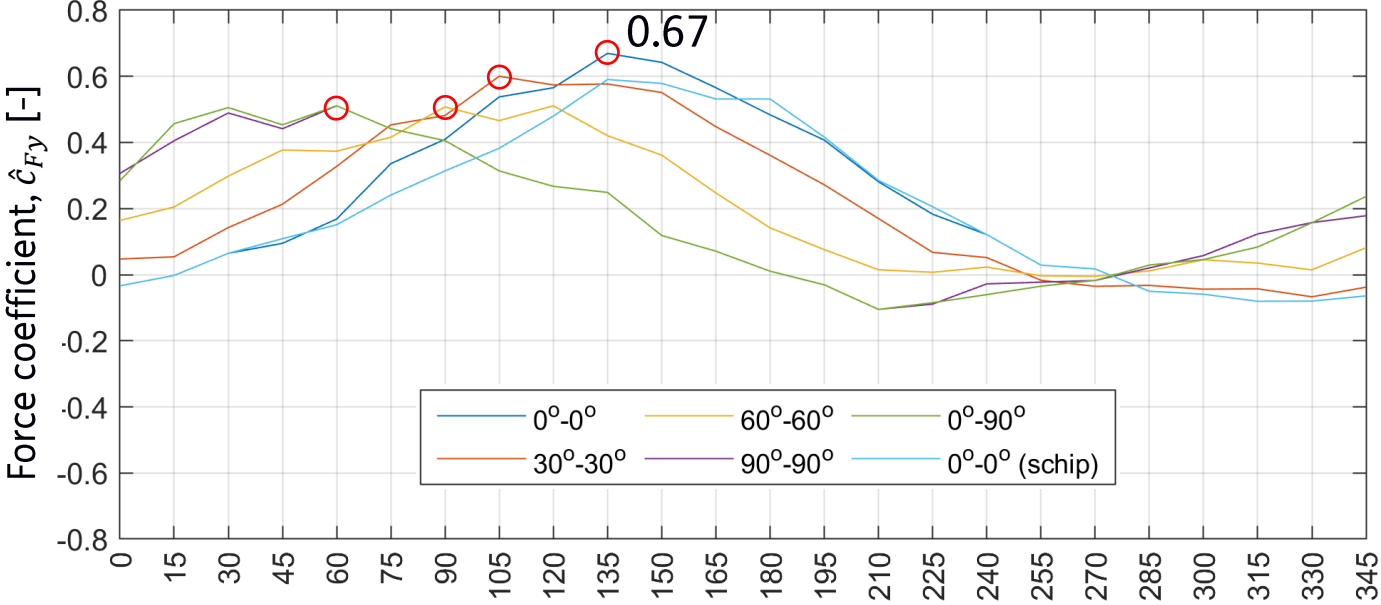
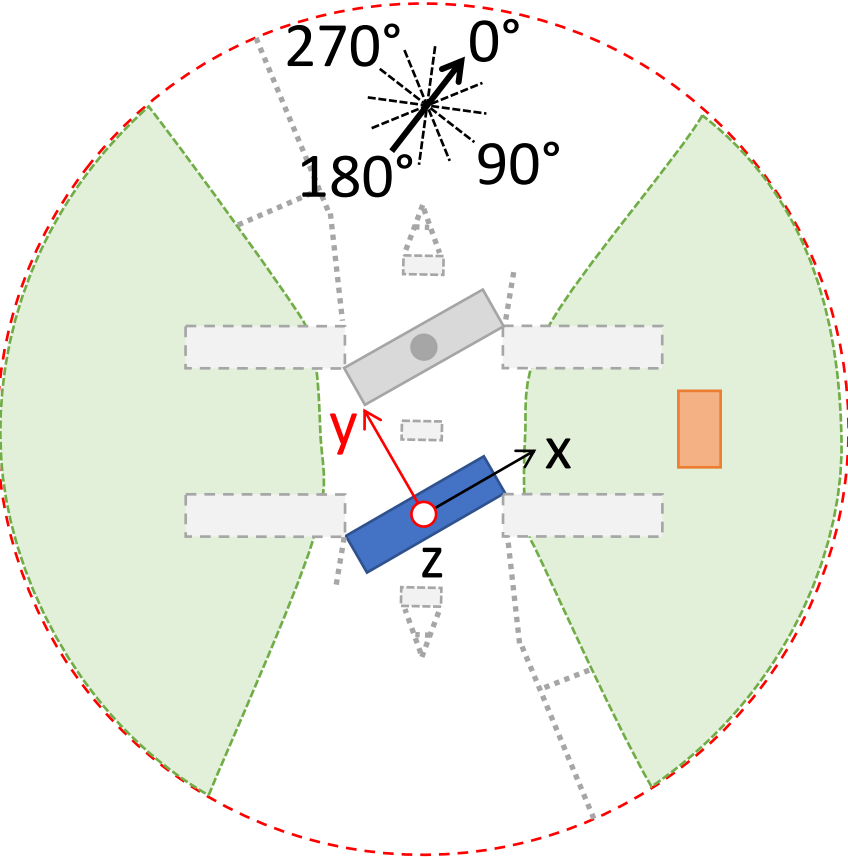
Results



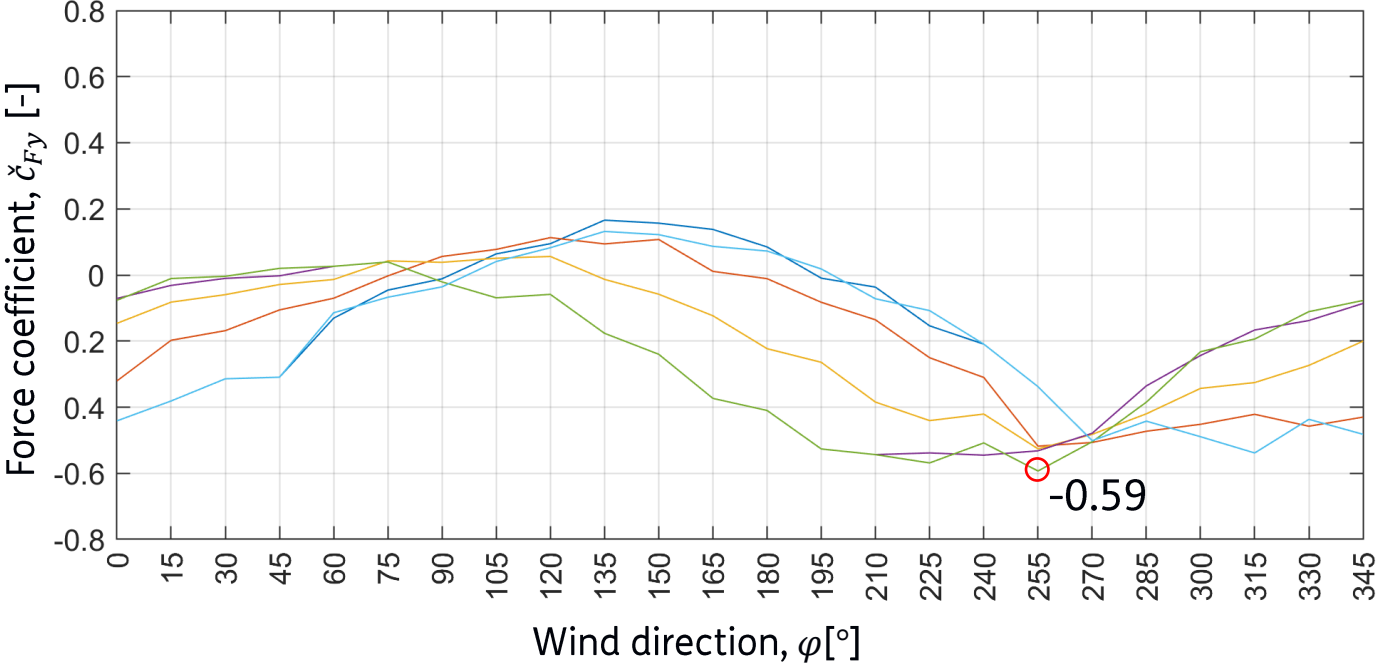
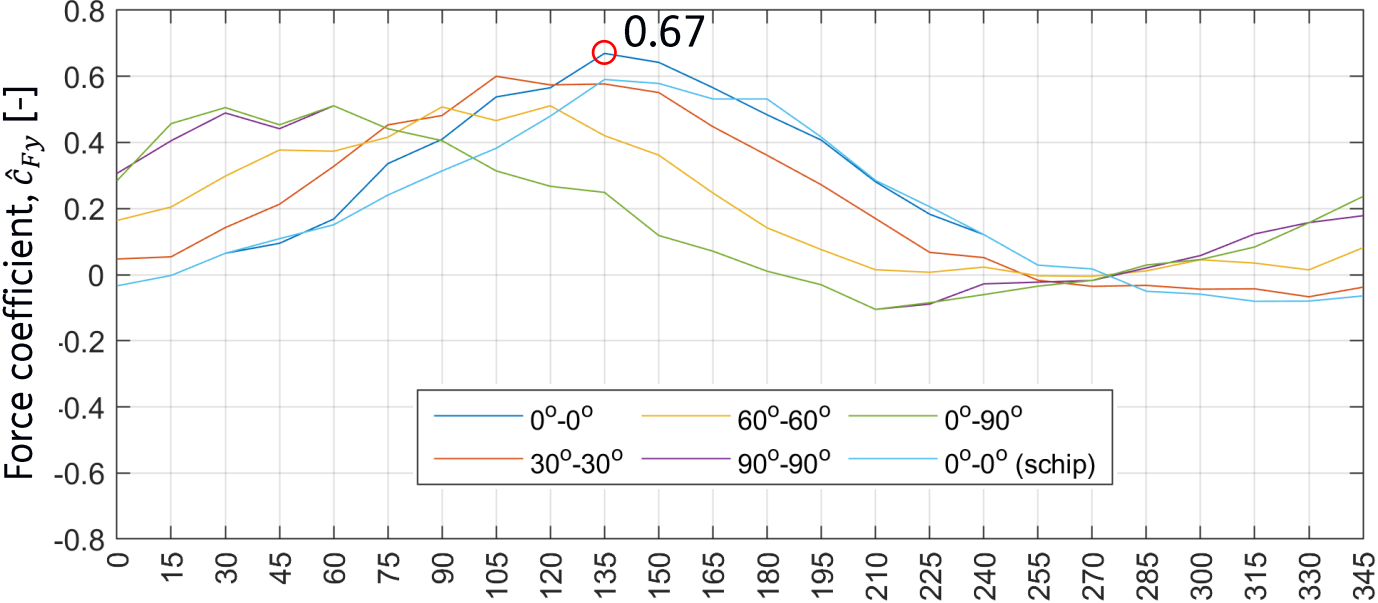
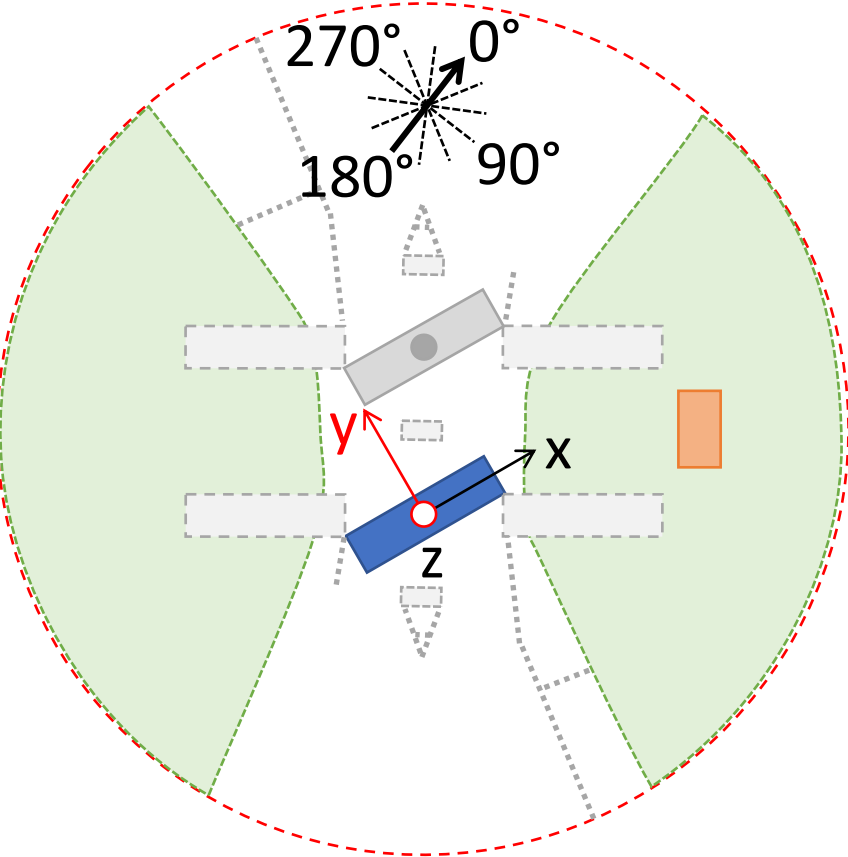
Results



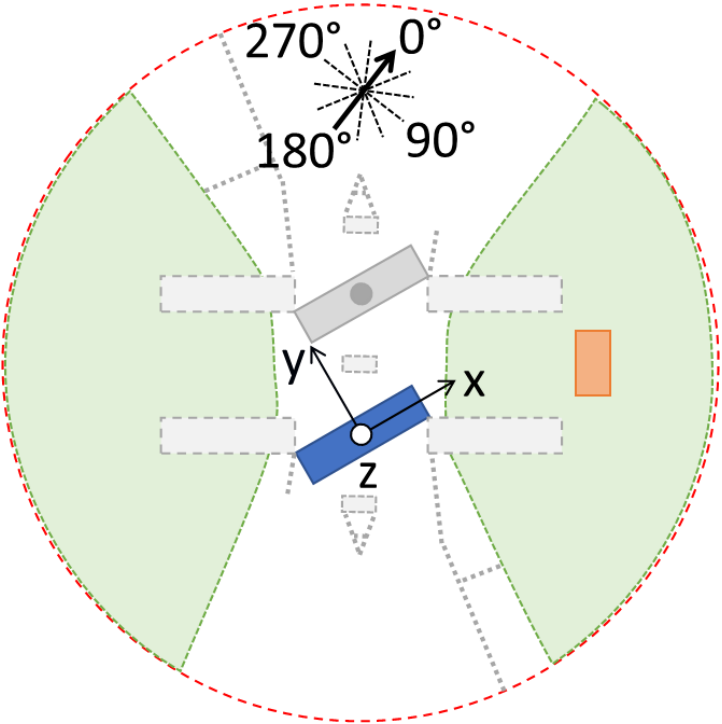
Results



Results



Results

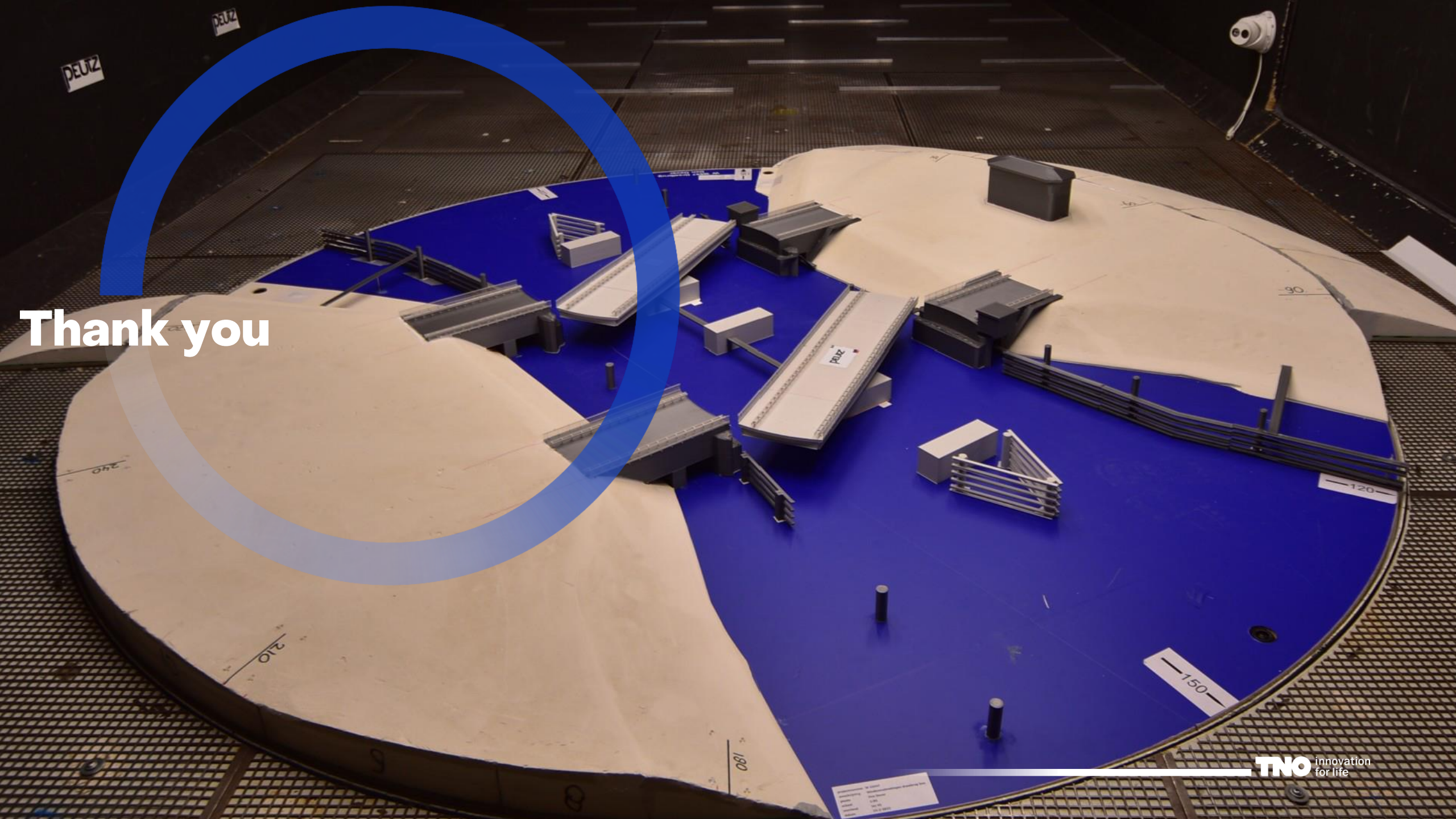


	C _{Fx}		C _{Fy}		C _{Fz}		C _{Mx}		C _{My}		C _{Mz}	
	max	min	max	min	max	min	max	min	max	min	max	min
Wind tunnel	0.31	-0.21	0.67	-0.59	0.42	-0.26	0.18	-0.23	0.18	-0.19	0.036	-0.032
NEN 6786-1	*	*	*	*	0.40	-0.40	*	*	0.06	-0.06	0.032	-0.032
EN 1991-1-4	0.52	-0.52	1.30	-1.30	0.90	-0.90	0.58	-0.58	-	-	0.064	-0.064

* NEN 6786-1 refers to NEN-EN 1991-1-4

Conclusion

- Literature wind loads on movable bridges limited
- Large differences in code provisions for wind loads
- Comparison with wind tunnel measurements
 - EN 1991-1-4: overestimation c_{Fx} , c_{Fy} , c_{Fz} , c_{Mx} and c_{Mz}
 - NEN 6786-1: c_{Fz} and c_{Mz} agree well, underestimation c_{My}



Thank you