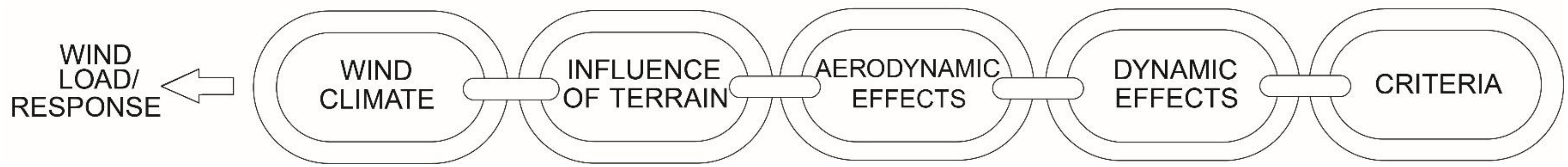
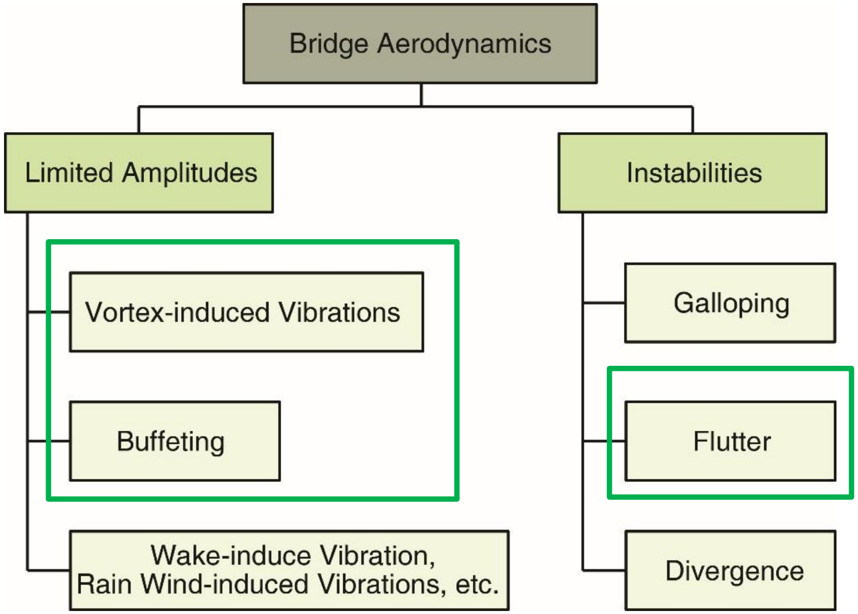
Project 6
Wind-induced Vibrations of Long-span Bridges

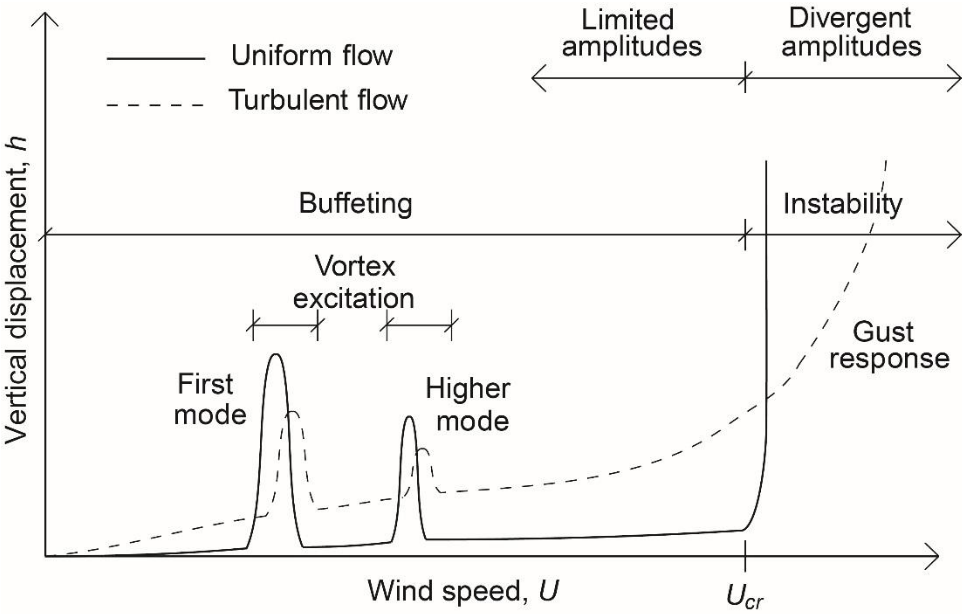
Motivation

- Long and slender structures
- Light weight
- Low structural damping

Wind Engineering (Design)







Vortex Induced Vibrations

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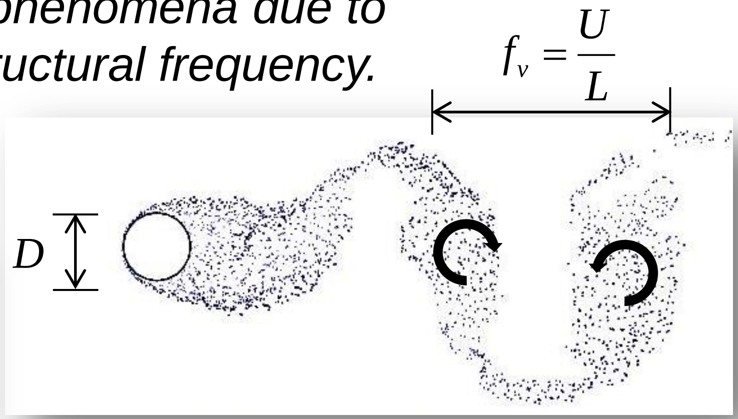
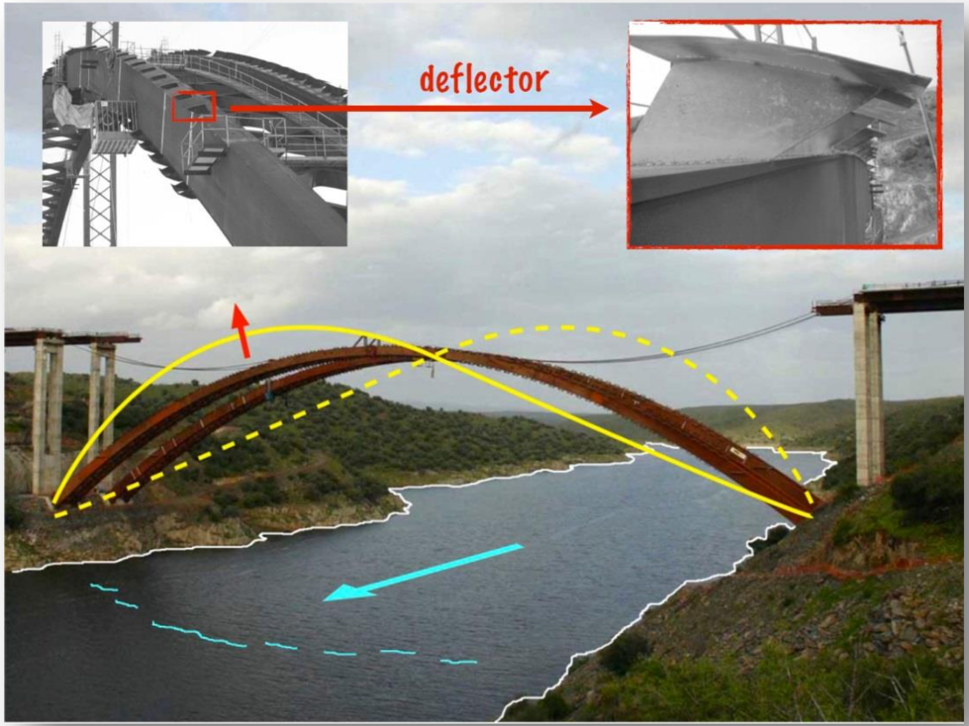
Vortex Induced Vibrations

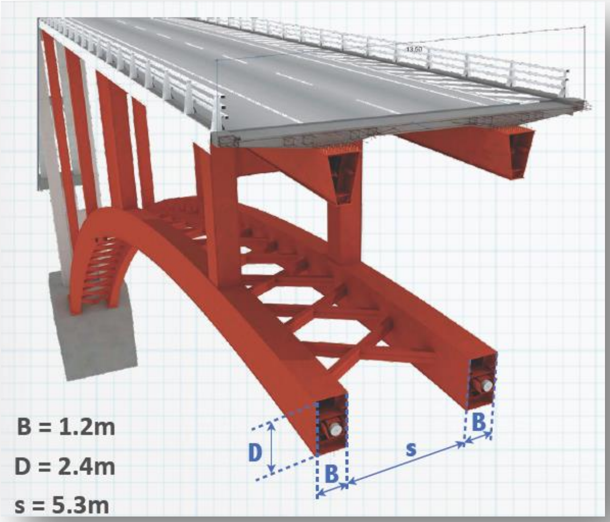
Vortex-induced vibrations (VIV) are resonance phenomena due to matching vortex shedding frequency and the structural frequency.

Lock-in ⟶ Resonance $f_v = (0{,}8 - 1{,}2)\, f_n$



Self-limiting phenomenon [1]





Motion of the Alconétar Bridge (upper) and its parameters (right) [1]

[1] Tajammal Abbas (2016) , PROJECT 6: WIND-INDUCED VIBRATIONS OF LONG-SPAN BRIDGES, Bauhaus Summer School 2016

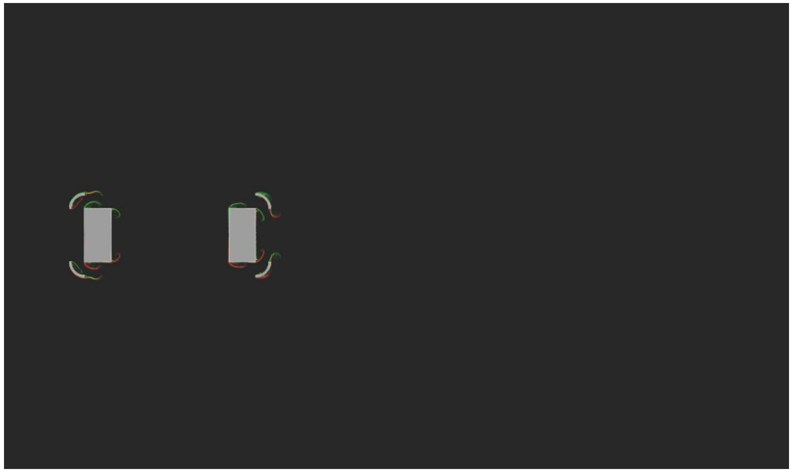
Vortex Induced Vibrations

Rectangular cross-section

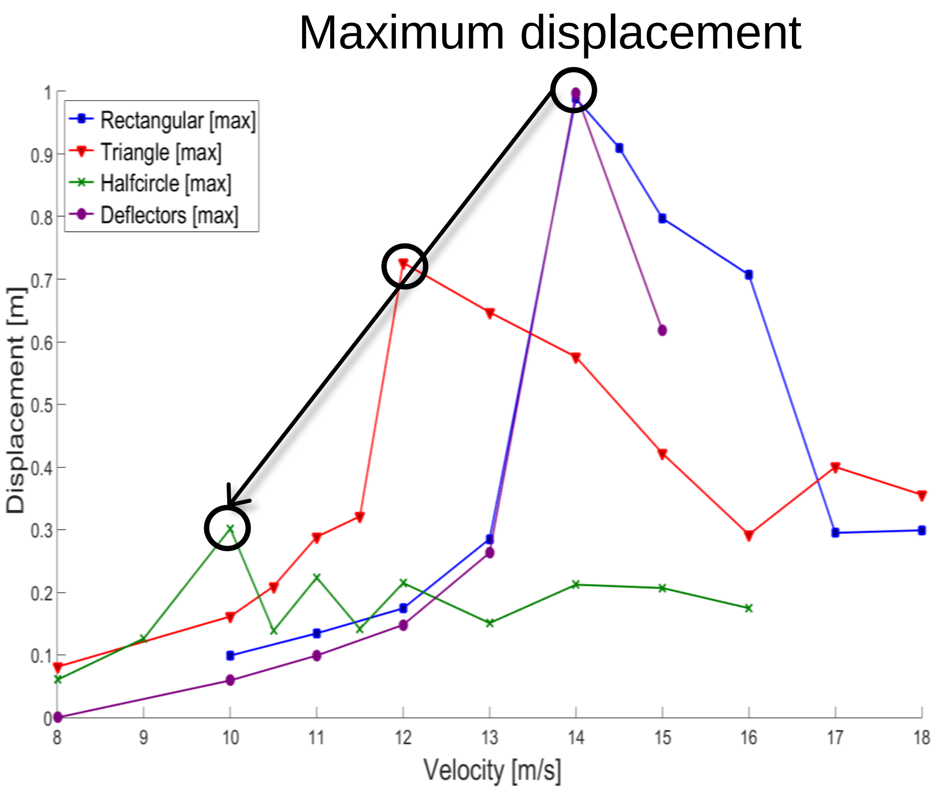
Rectangular + half-circle cross-section

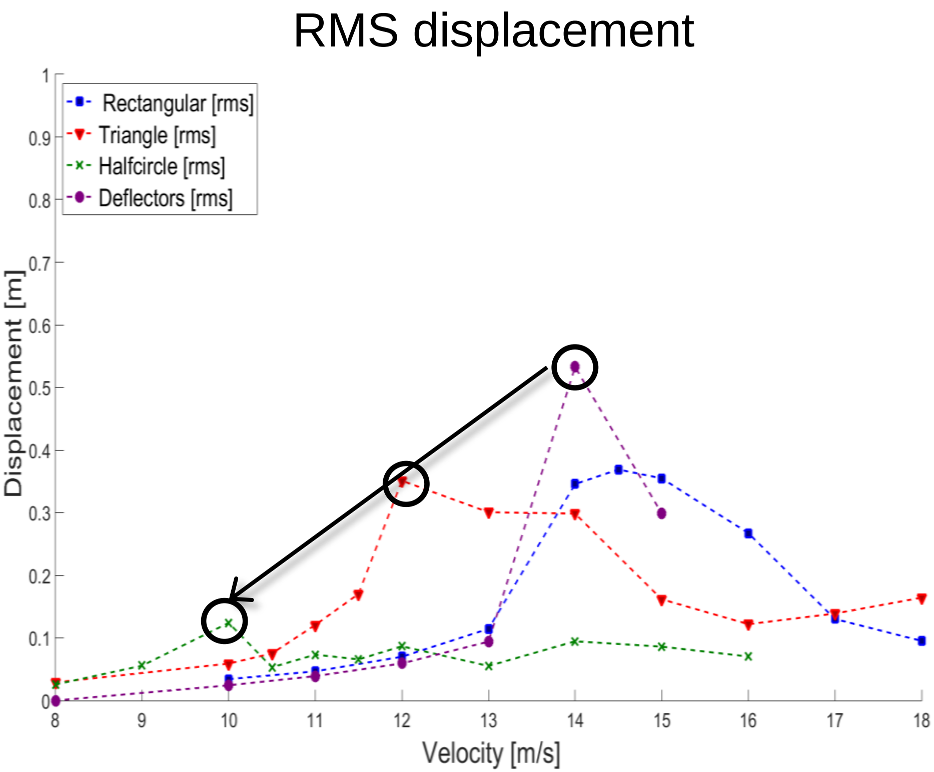
Pentagon cross-section

Rectangular + deflectors cross-section

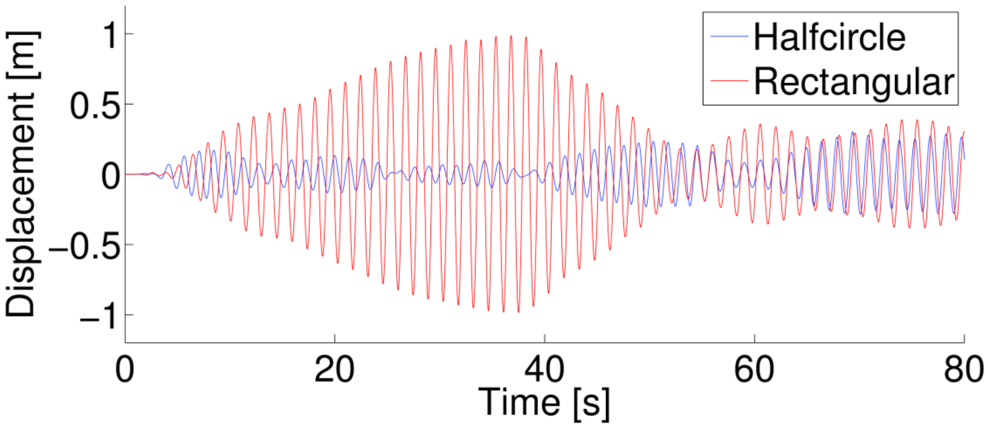


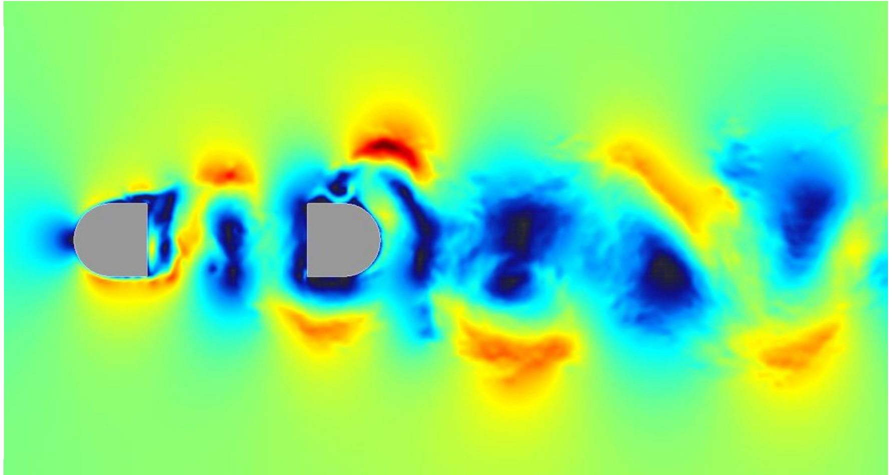
Comparison of displacements





Optimazied shape – Halfcircle





Conlusion

- VIV is self-limiting phenomena, not destructive
- Fatigue problems, comfort issues
- Influence of geometrical shape on VIV

Outlook

- TMD can be studied
- Moveable flaps

Buffeting analysis

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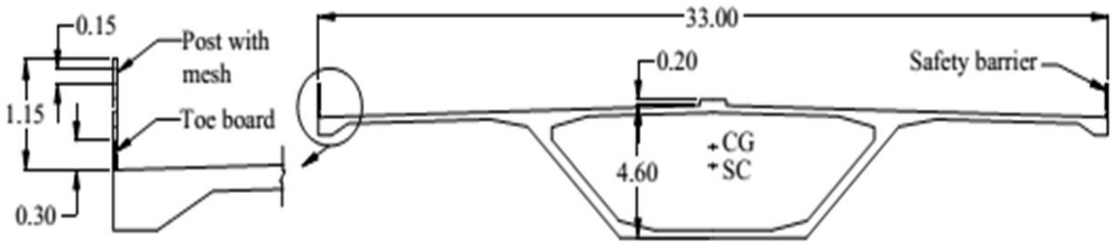
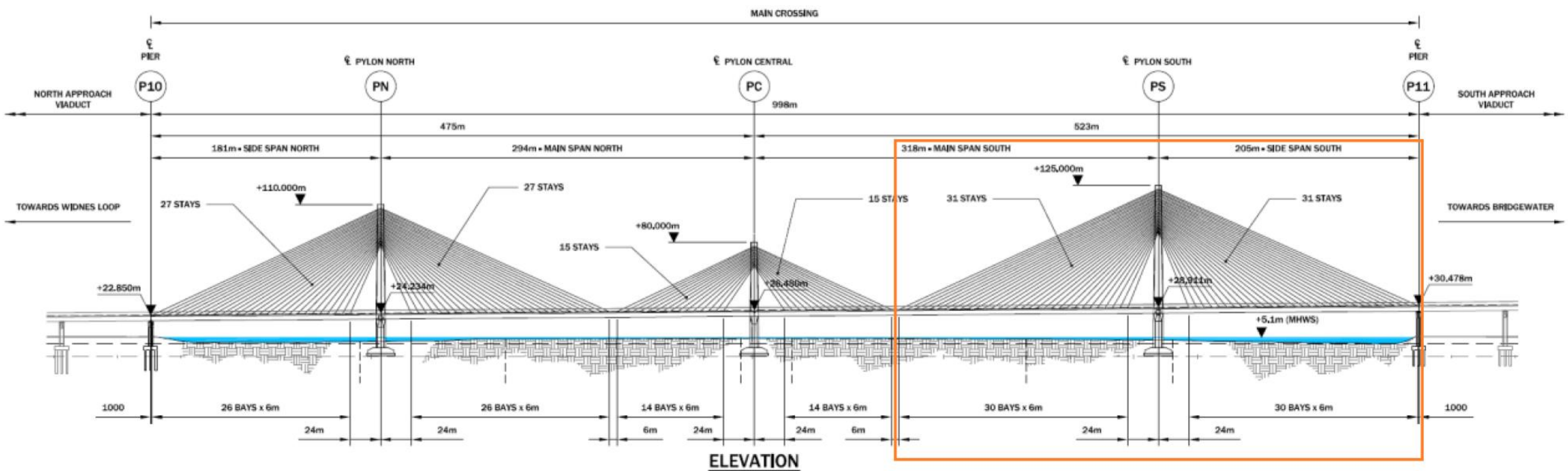
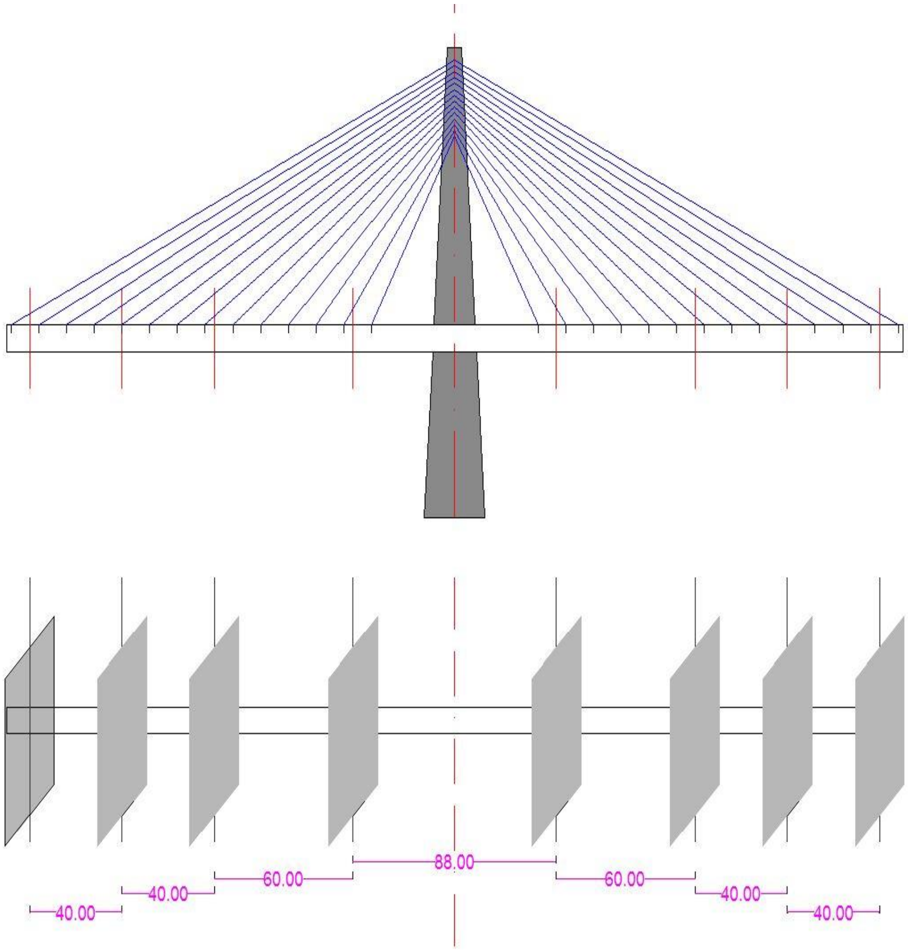
Buffeting excitation is caused by fluctuating forces induced by inflow turbulence in the wind field**.**

Reference object

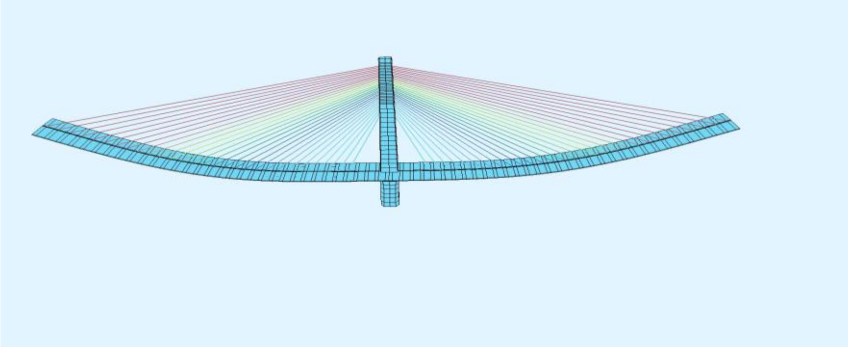




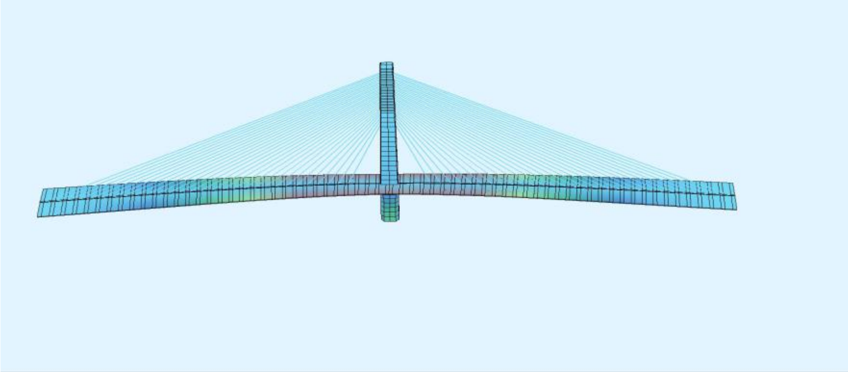
Structural system and discretization



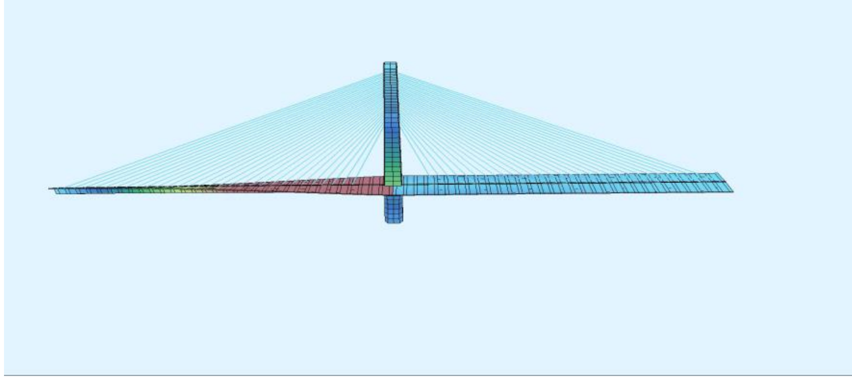
Distance [m]



f_V = 0.401 Hz

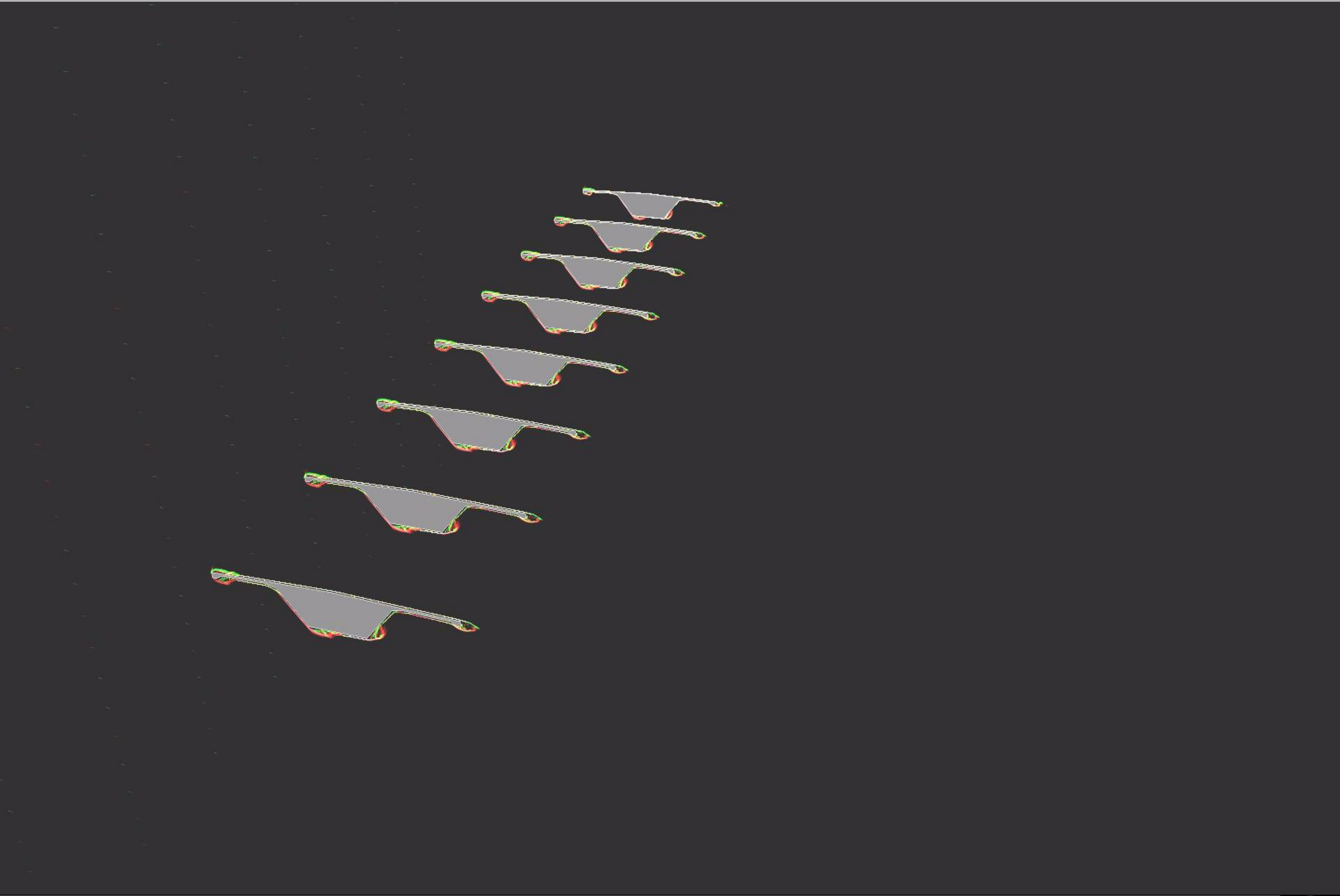


f_L = 0.444 Hz



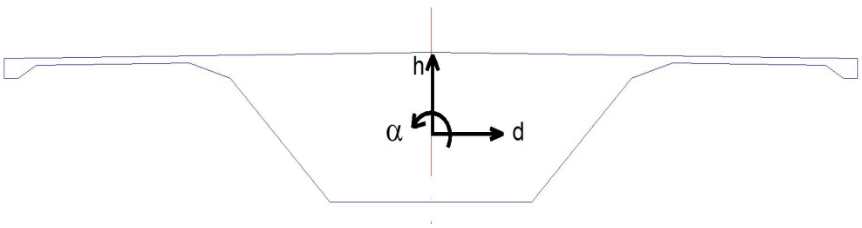
f_T = 0.913 Hz

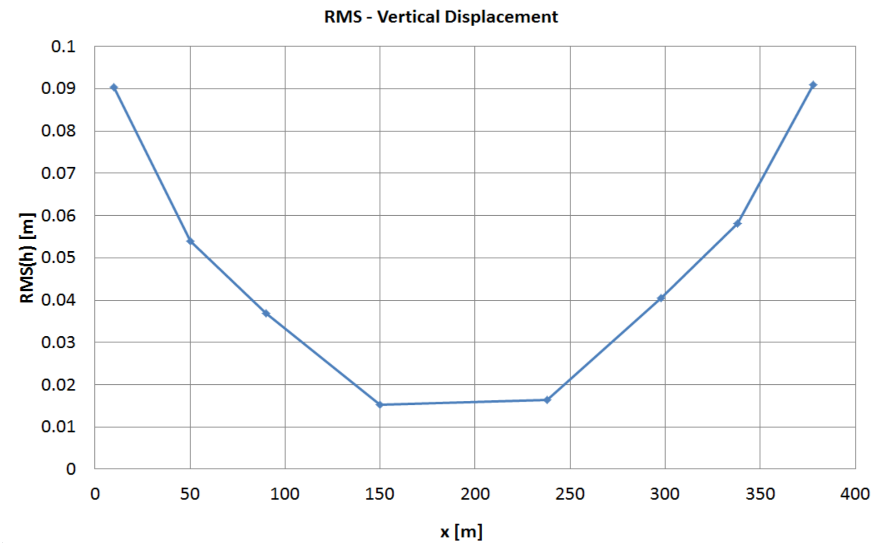
BUFFETING RESPONSE

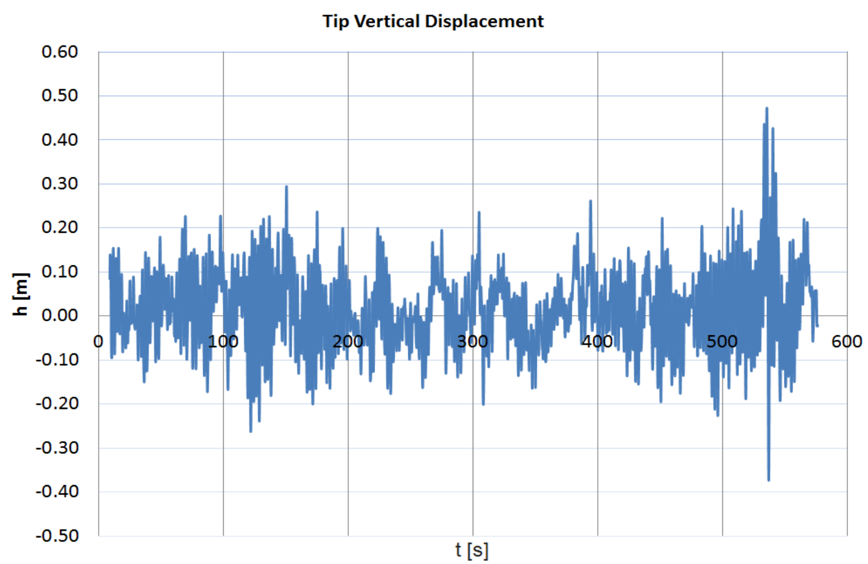


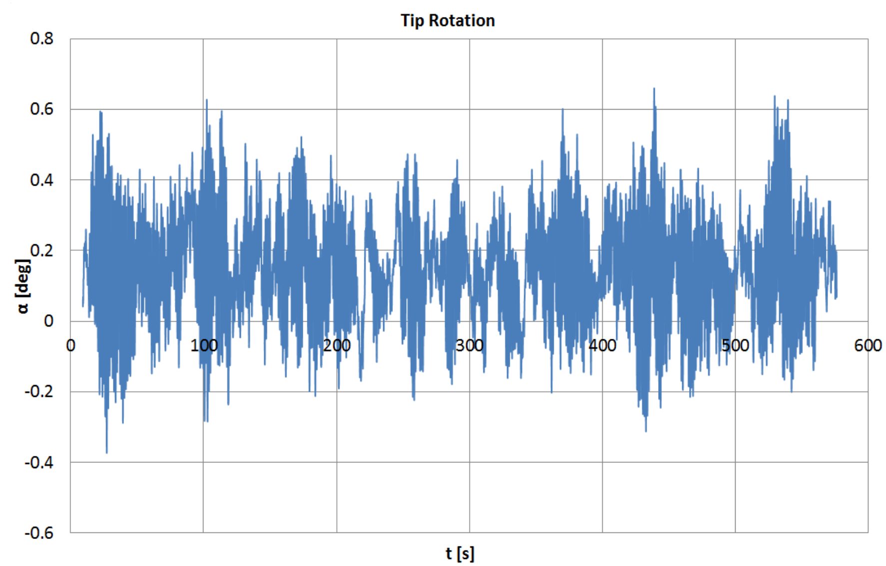
Structural Response

U=55 m/s, *Tu*=*Tw*=10%.









Flutter

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ŠPIRIĆ, Stefan
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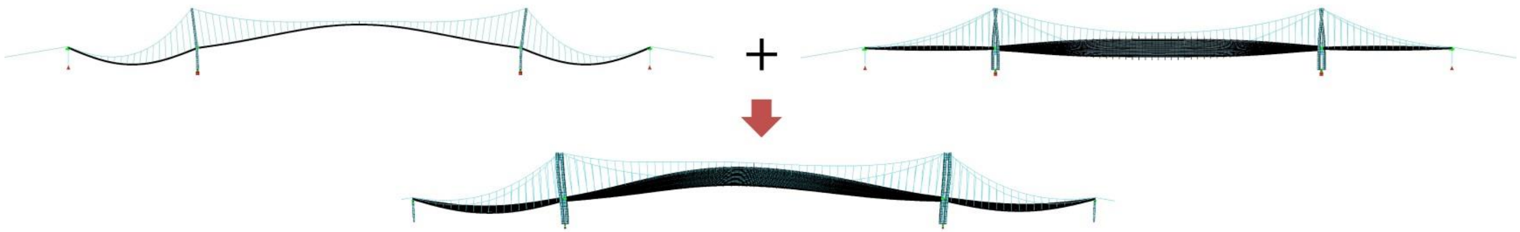
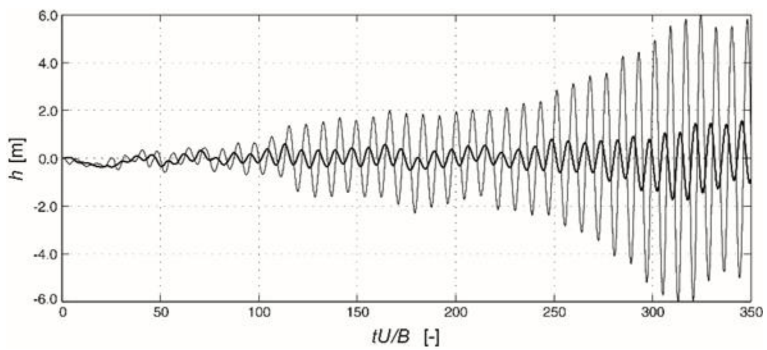
Flutter

- Coupling of vertical and torsional oscilating mode
- Aeroelastic instability at higher wind speeds
- Can cause ULS if not taken into account



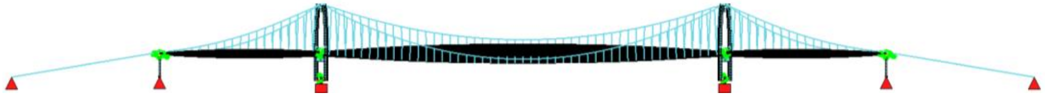


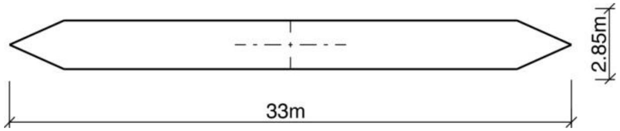
Lillebælt Suspension Bridge, Denmark

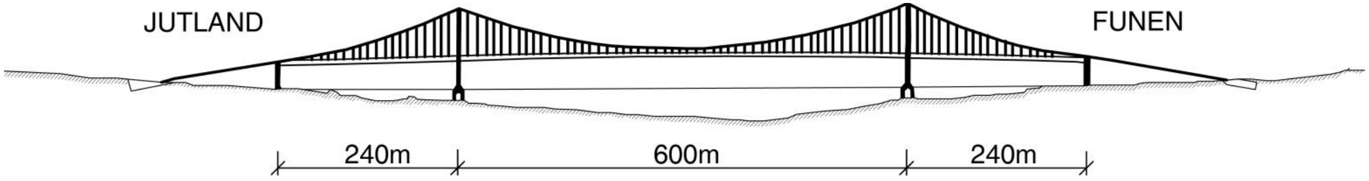
- Total length 1080 m
- Steel box girder deck section

0,156 Hz

0,5 Hz







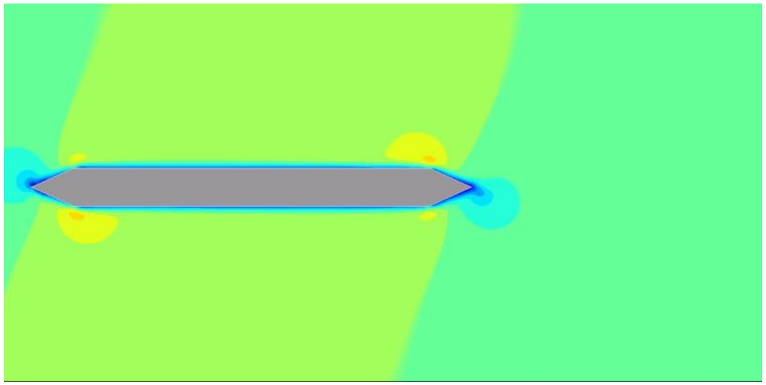
Analysis Methods

Analysis Methods	1. Fully analytical
	2. Forced vibrations
	3. Fully coupled CFD simulation

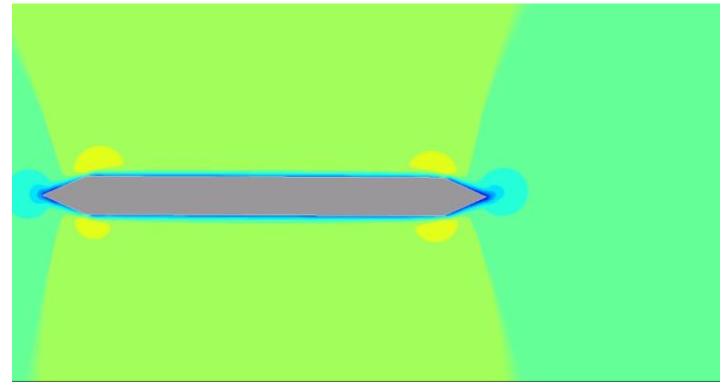
1. Potential flow theory, analytical aerodynamic and structural model
2. Numerical aerodynamic model and analytical structural model
3. Numerical aerodynamic and strucural model

Forced Vibrations

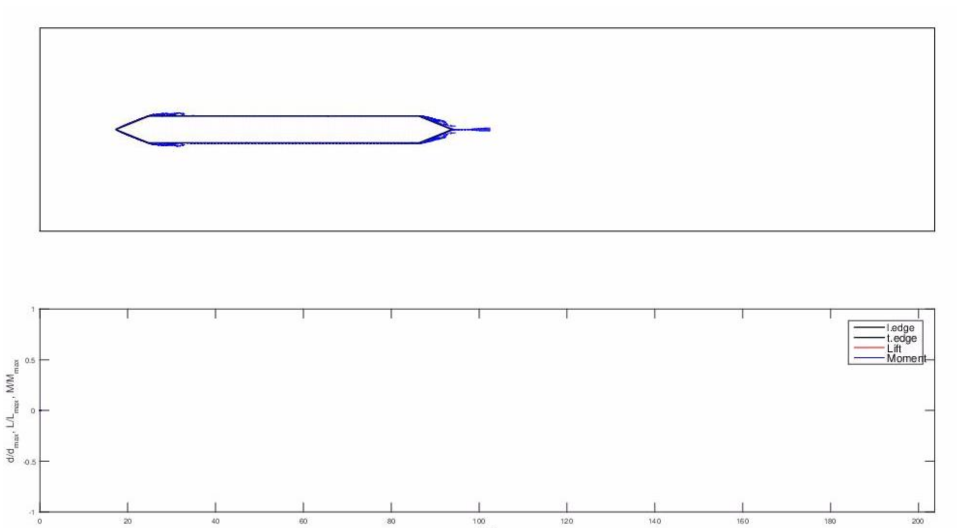
Heave



Pitch



Fully coupled CFD – single slice



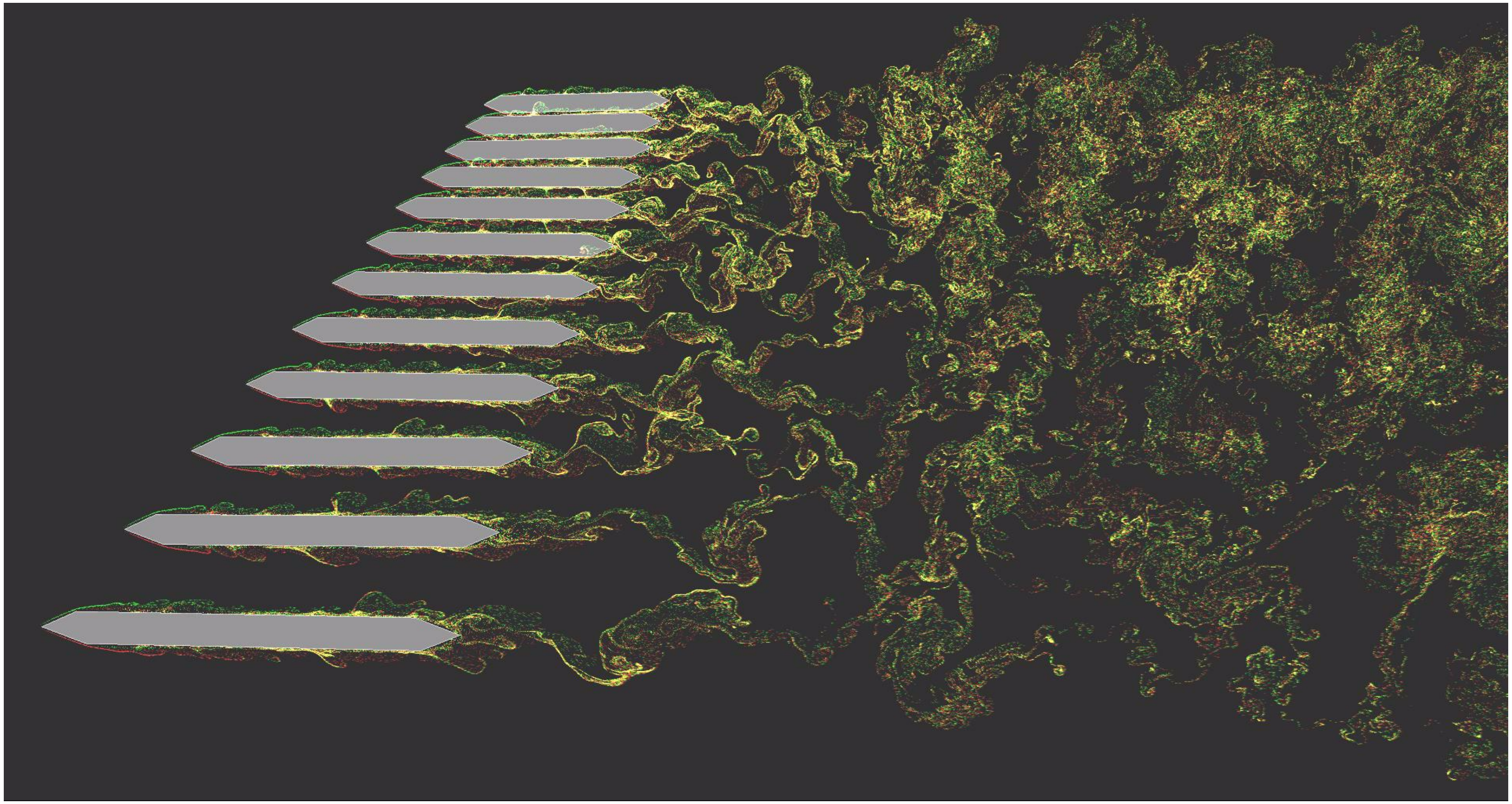
Critical wind velocities

$U_{cr,Theodorsen}$ = 94 m/s

$U_{cr,Scanlan}$ = 101 m/s

$U_{cr,CFD}$ = 98 m/s

Fully coupled CFD – Multi slice



Conclusion