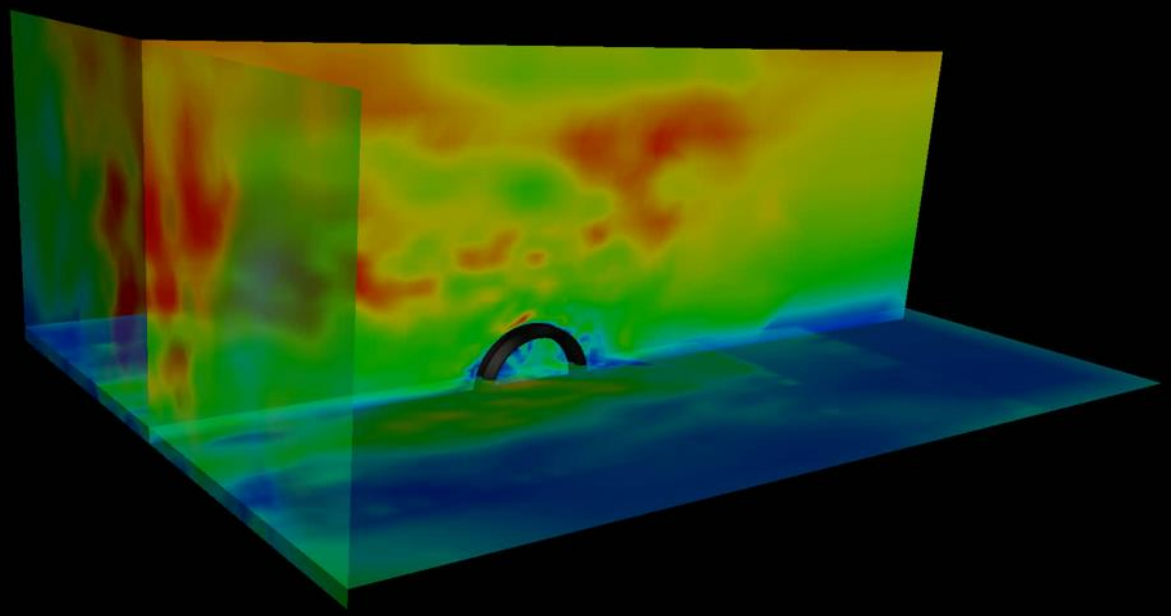
Chair of Structural Analysis
TUM Department of Civil, Geo and Environmental Engineering
Technical University of Munich



STRUCTURAL WIND ENGINEERING

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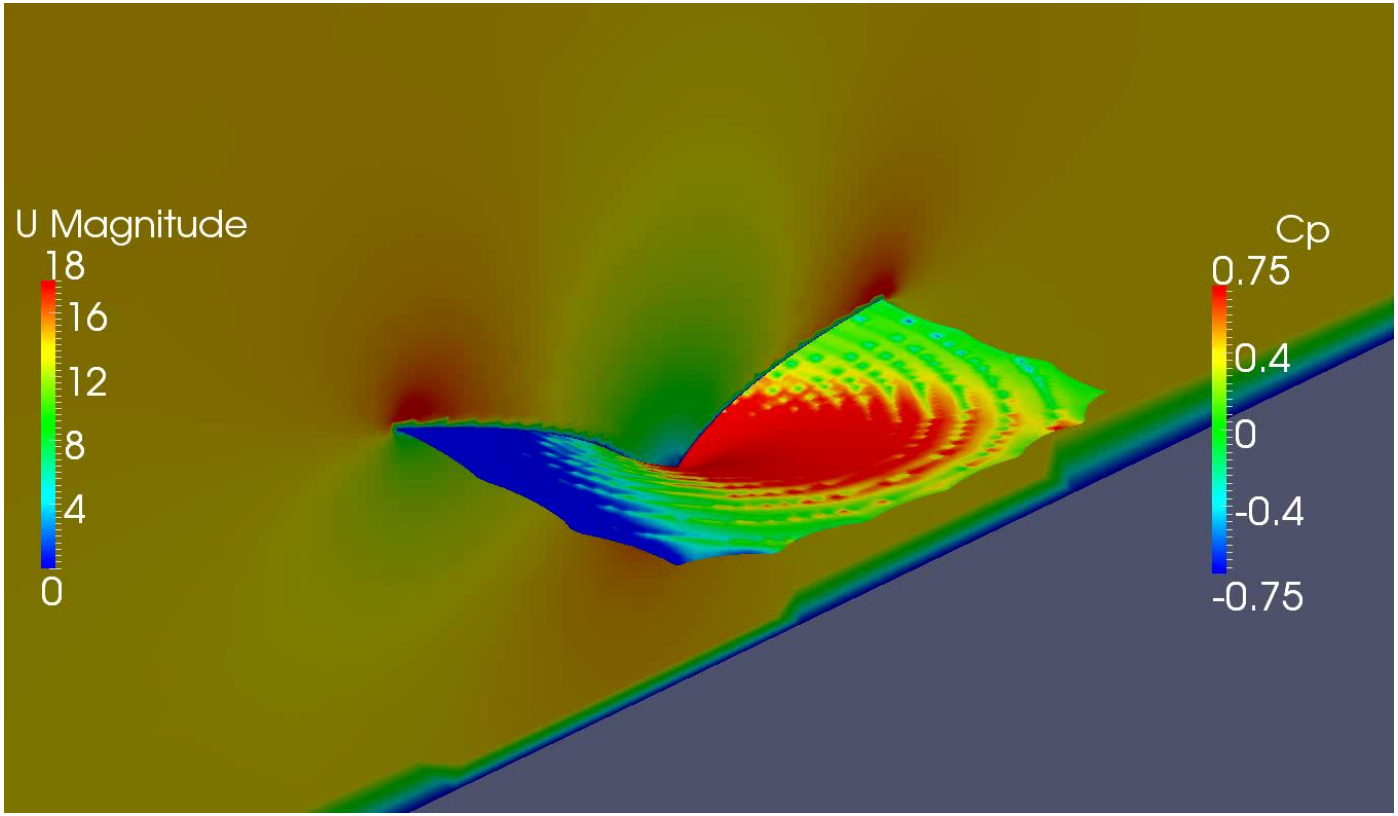
Presentation material from internal and external sources have been used either directly, modified or adapted to fit the purpose. Effort is continuously being made to accurately reference these. Nonetheless, check referencing in both the script as well as slides for completeness. In case of inconsistencies or mistakes please contact us!

Disclaimer: Some selected aspects related to a correct setup of a CFD simulation are presented. For exhaustive insight and information refer to specialty literature, such as the ones recommended on the last slide.

Best Practice Guidelines for CWE

Introduction

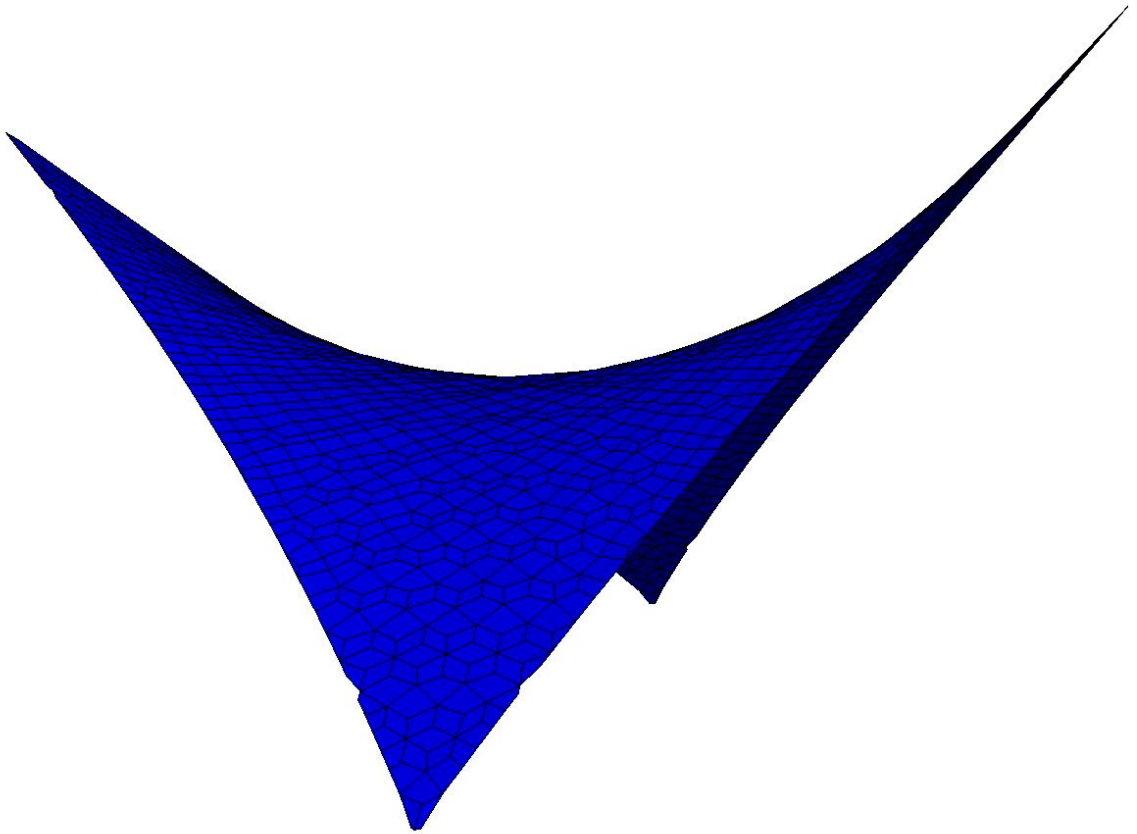
- CWE:
  - CFD



Best Practice Guidelines for CWE

Introduction

- CWE:
  - CFD
  - FSI



Best Practice Guidelines for CWE

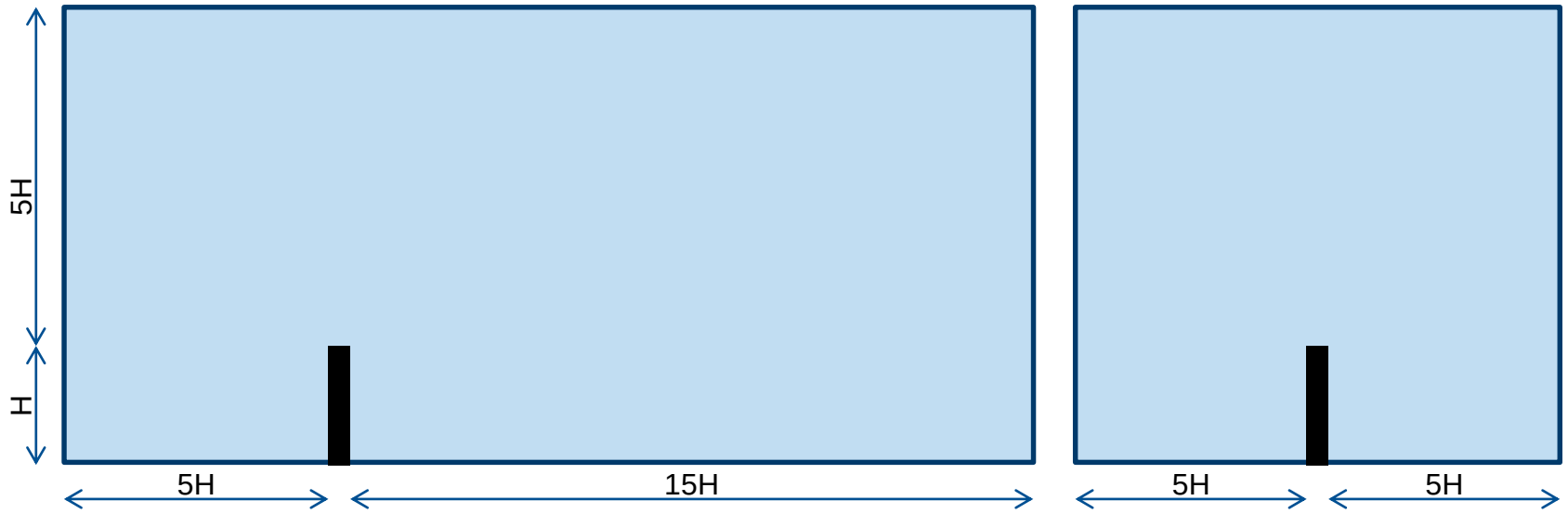
Introduction

- CWE:
  - CFD
  - FSI = CFD + CSD

Best Practice Guidelines for CWE

1 - Computational Domain

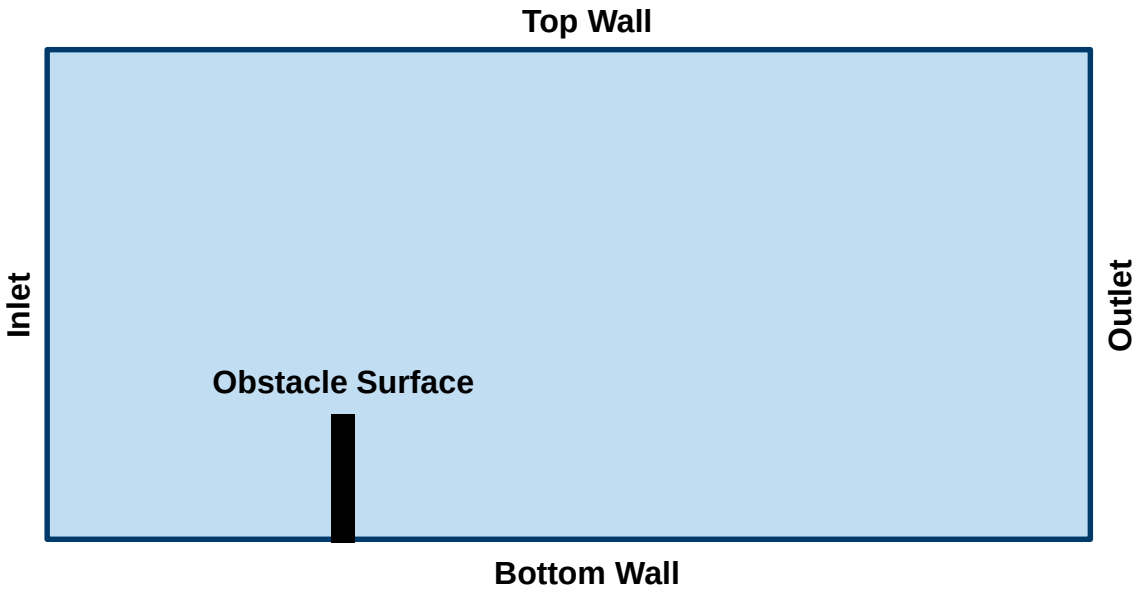
- 3D
- Enough clearance from the boundaries:
  - 5H clearance from the inlet, sides, and top boundries.
  - 15H clearance from the outlet.
- < 3% Blockage ratio.

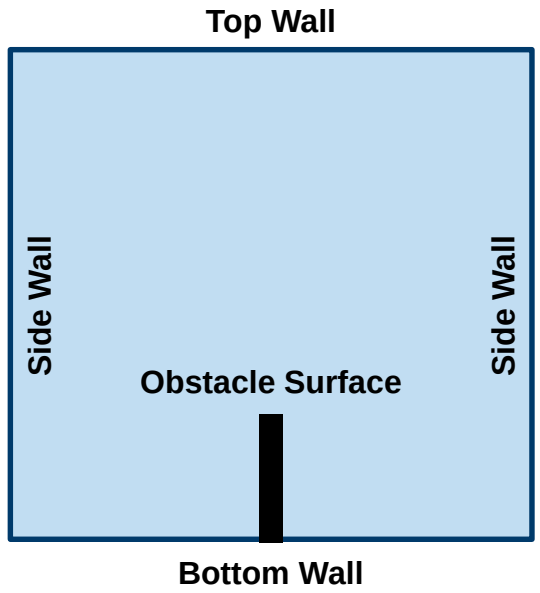


Best Practice Guidelines for CWE

2 - Boundary Conditions

- **Inlet**: zero gradient of Pressure and prescribed Velocity field.
- **Outlet**: Zero Pressure field and zero gradient of Velocity.
- **Top Wall & Side Walls**: Slip boundary condition (Symmetry)
- **Bottom Wall & Obstacle Surface**: non-Slip boundary condition.

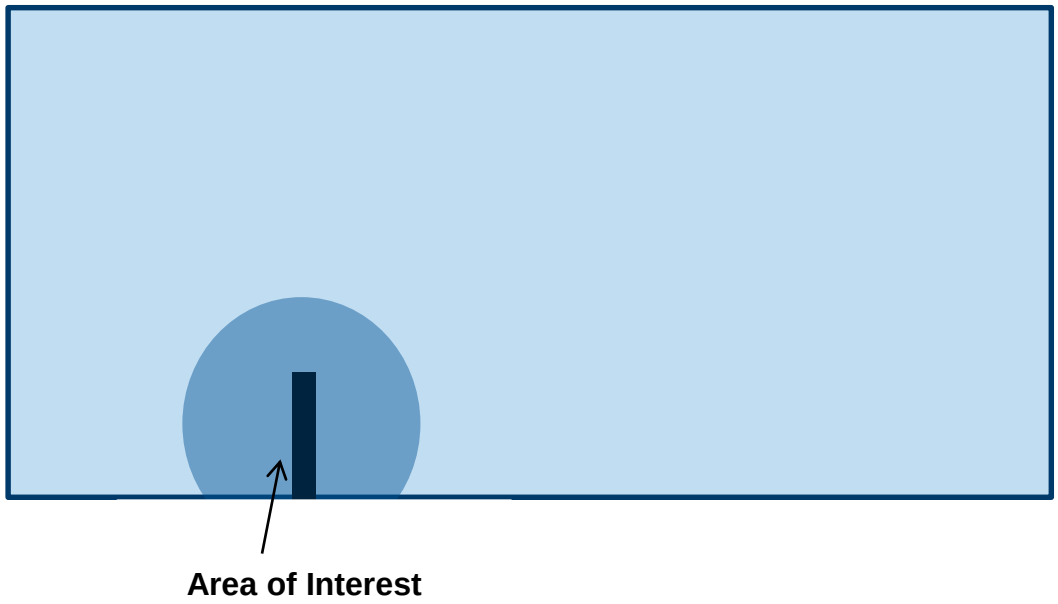




Best Practice Guidelines for CWE

3 - Element Size

- At the area of interest at least 10 cells per cubic root of the building volume should be used.



Best Practice Guidelines for CWE

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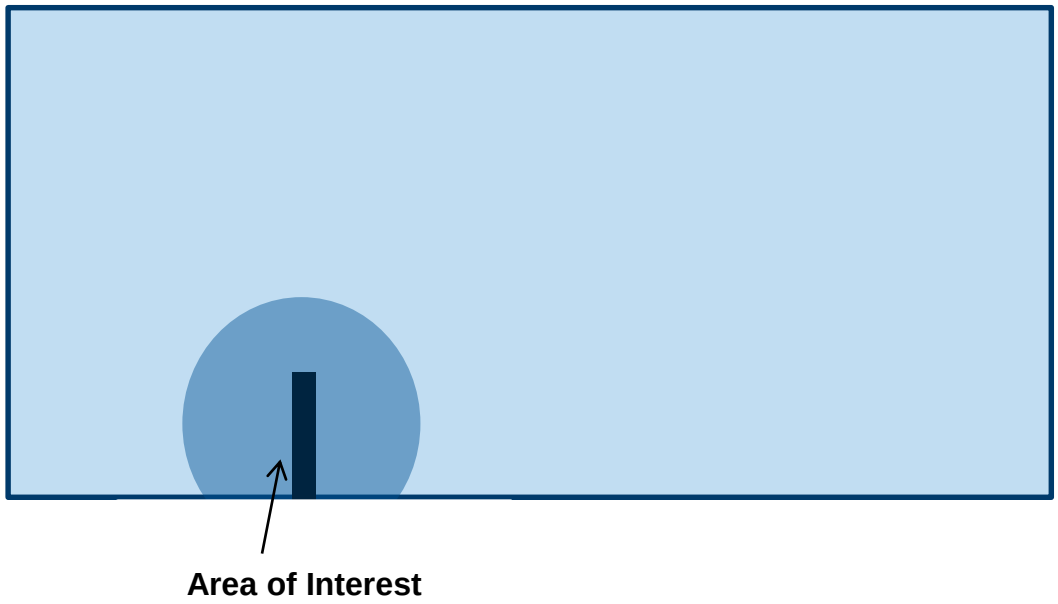
- Clear representation of the interesting features.



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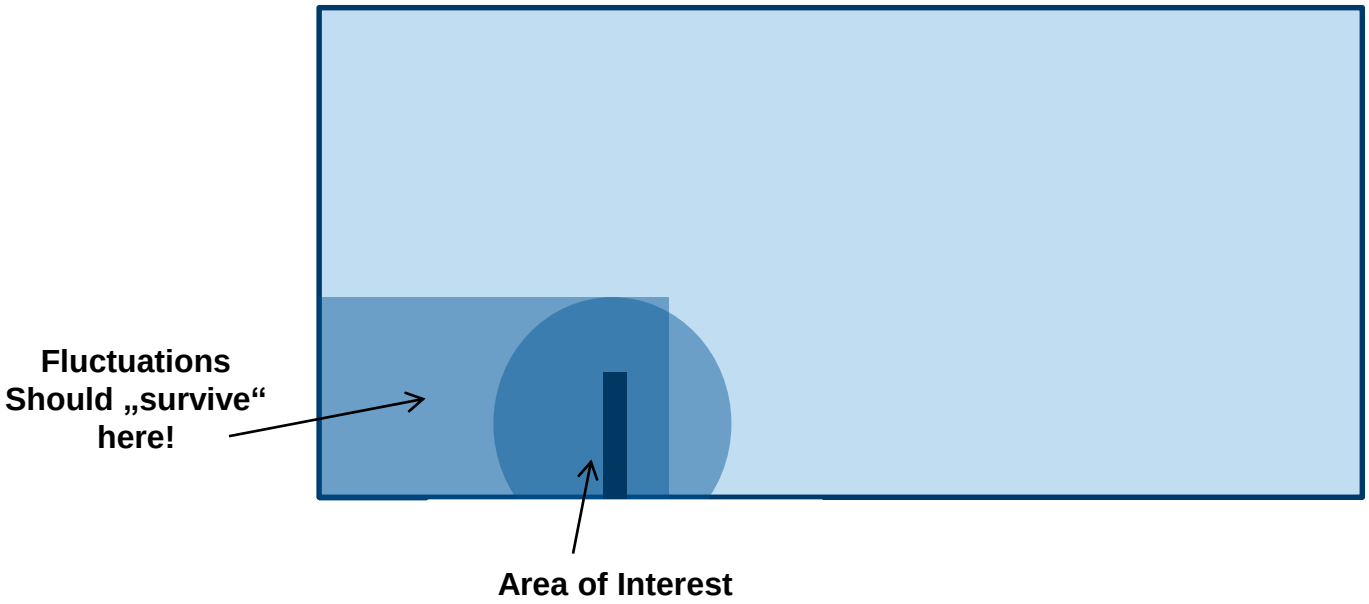

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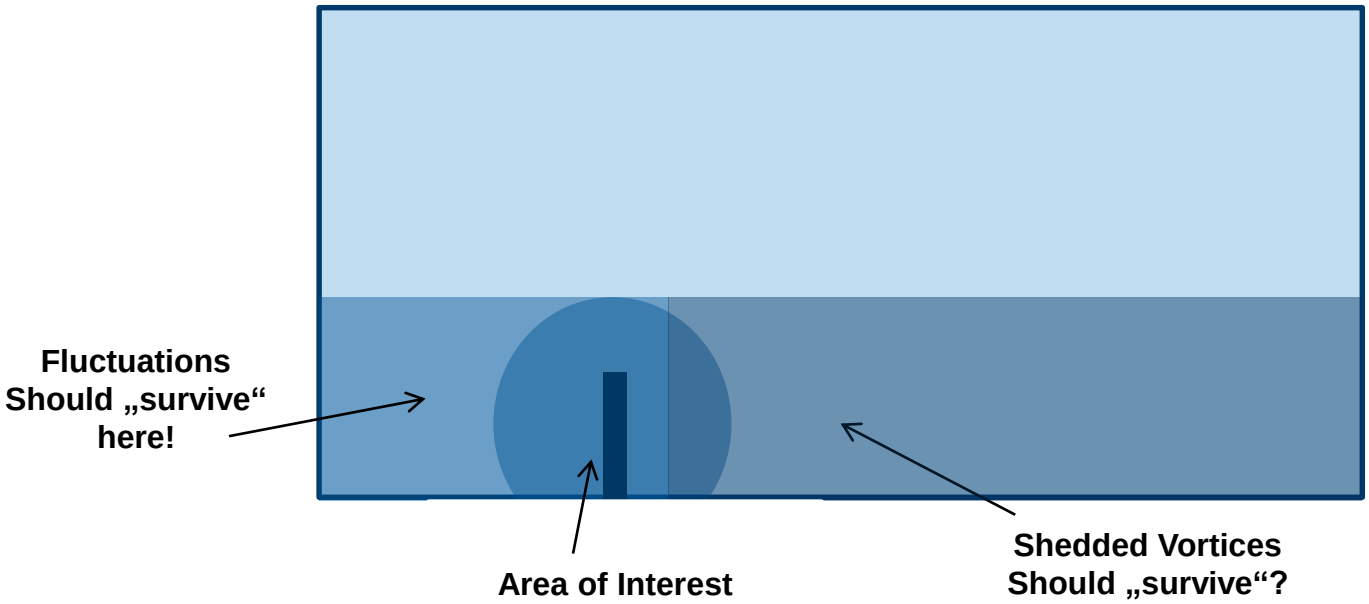
- Conservation of wind fluctuations.
- Conservation of shedded vortices?



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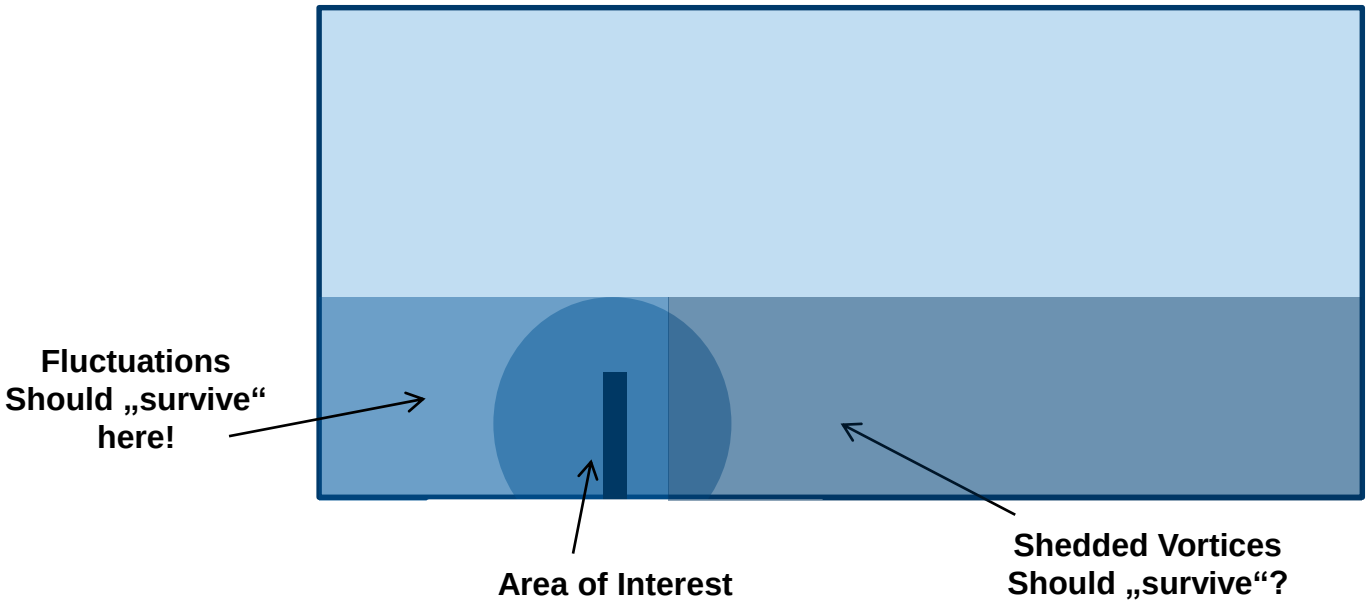
- Conservation of wind fluctuations.
- Conservation of shedded vortices?
- Mesh convergence study.



Best Practice Guidelines for CWE

4 - Time Step Size

- 10 – 20 time steps per „interesting“ period.
- Small enough to conserve solution stabitity (CFL Number).
- Convergence study.

Best Practice Guidelines for CWE

5 - Turbulence Closure Solution

- LES (in FVM) & VMS (in FEM) are to be used.

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6 - Numerical Schemes

- First order schemes (e.g. UpWind schemes for spatial discretisation and 1st order Euler for temporal discretisation) should **NOT** be used to avoid numerical diffusion.
- Second order schemes are to be used:
  - **2nd order central differencing** for spatial discretisation
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7 - Iterative solution termination criterion

- Equations‘ residuals should tend toward zero. Termination criterion of e^{-5} is recommended.

Best Practice Guidelines for CWE

8 - Preparation for Post-processing

Depending on the purpose of the simulation:

- Global evaluations: Global resutant forces/coefficents.
- Local evaluations: Local Pressure Coefficients C_p.

Best Practice Guidelines for CWE

For more about the subject:

- Jorg Franke, Antti Hellsten, Heinke Schlünzen, and Bertrand Carissimo. *Best Practice Guideline for The CFD Simulation of Flows in The Urban Environment (COST Action 732).* University of Hamburg, 2007.
  (http://theairshed.com/pdf/COST%20732%20Best%20Practice%20Guideline%20May%202007.pdf)

- Jorg Franke et al. *Recommendations on the Use of CFD in Wind Engineering.* KU Leuven
  (https://www.kuleuven.be/bwf/projects/annex41/protected/data/Recommendations%20for%20CFD%20in%20wind%20engineering.pdf)

- Bert Blocken. 50 years of Computational Wind Engineering: Past, present and future*. 6th European and African Conference on Wind Engineering, Cambridge, UK, July 7-11, 2013*
  (http://www.urbanphysics.net/2014_JWEIA_Blocken_Review__Preprint.pdf)