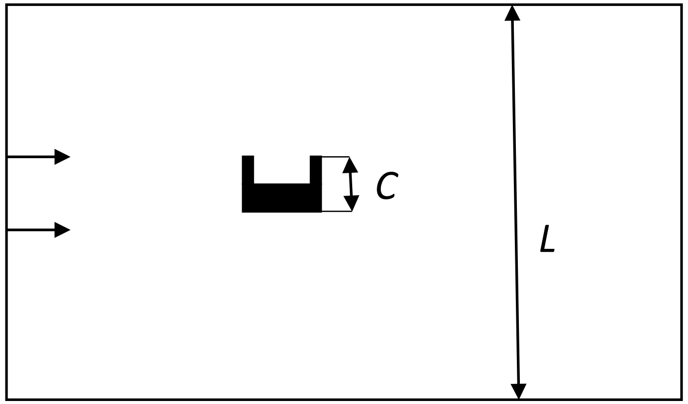
RANS modelling of the influence of the blockage effect in the wind tunnel

Blanka Ledvinková
Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences.

- blockage effect- due to presence of confined walls at wind tunnel
- presence of body-reduction of tunnel cross-sectional area, increase of the local velocity and possible distortion of flow pattern
- blockage ratio =*C/L*



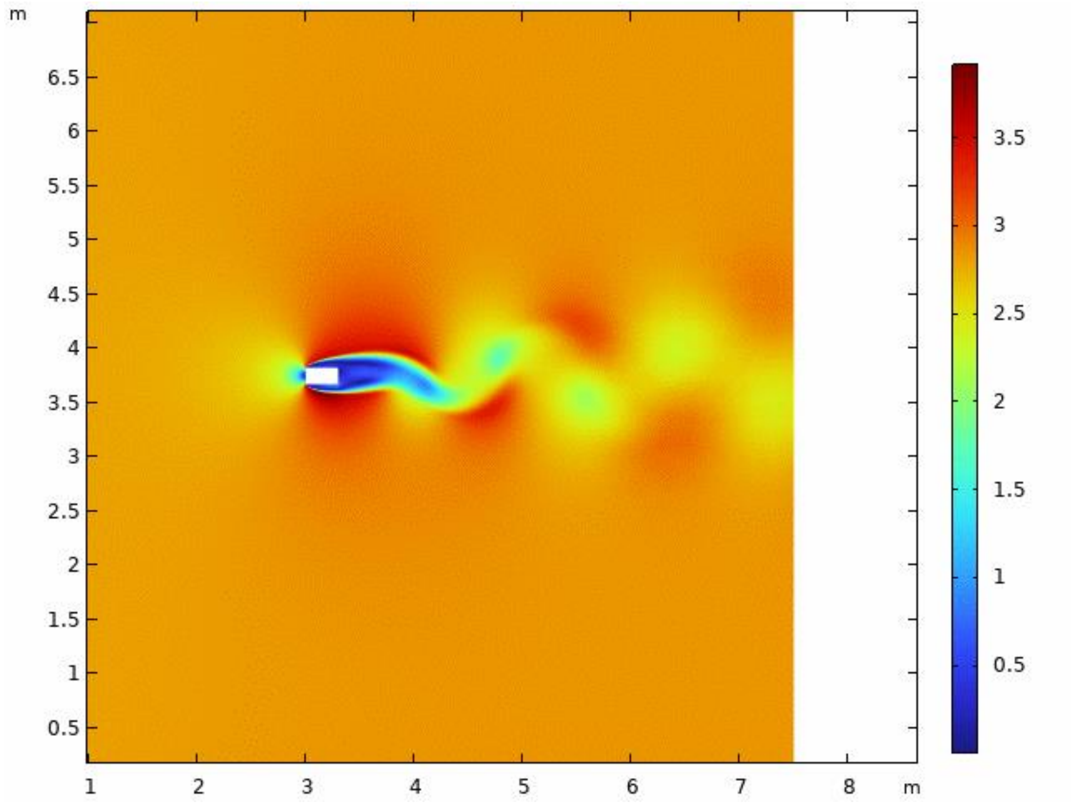
Numerical modelling

- 2d simulations using RANS k-ω SST model
- evaluation of aerodynamic coefficients and Strouhal number and flow characteristics

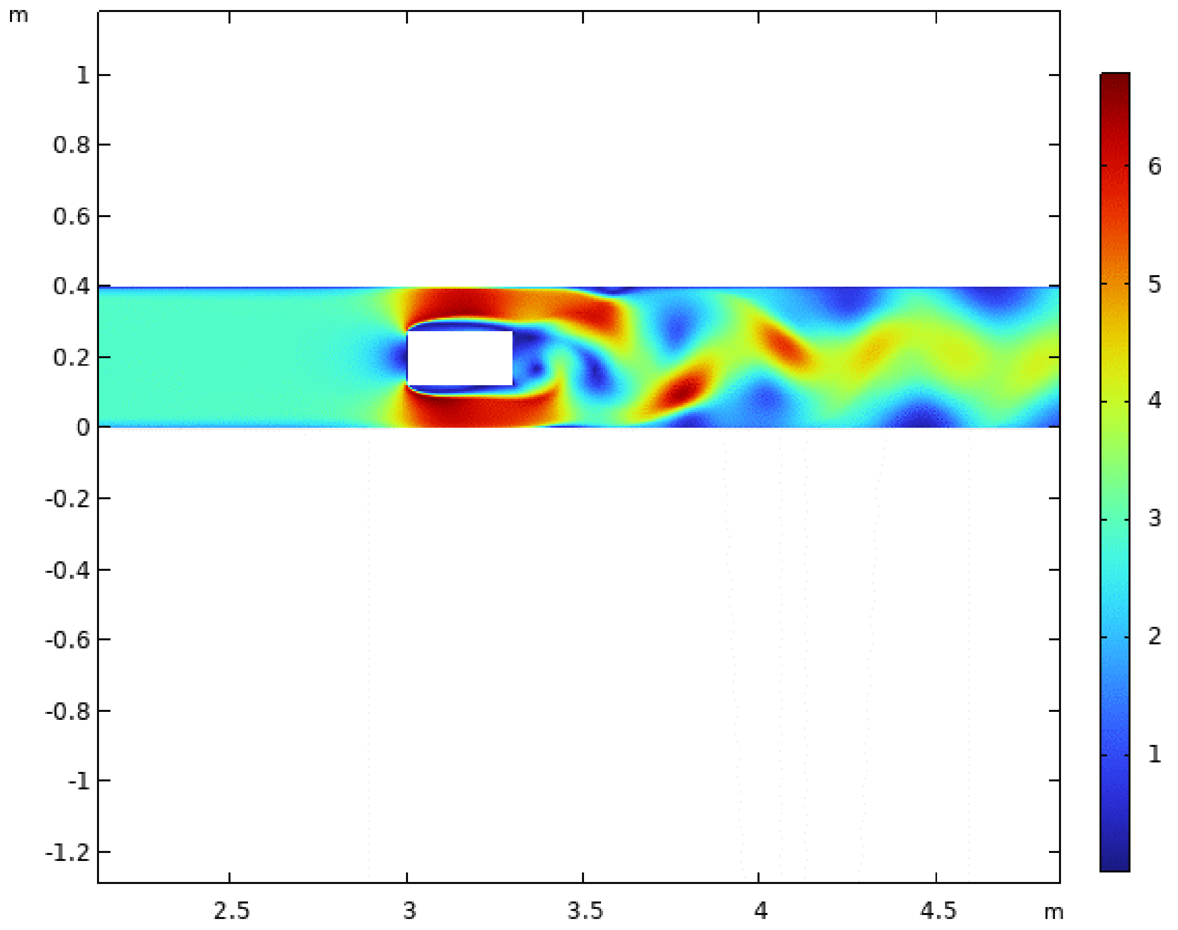
Blockage effect

calculation domains having different width

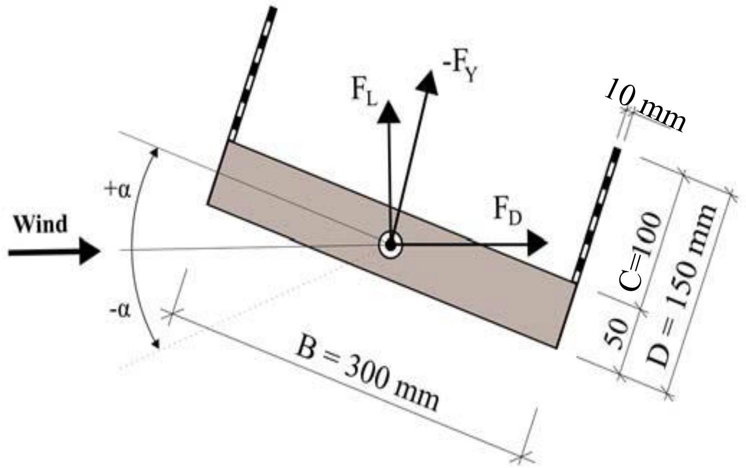
L=7.5m, C=0.15m



L=0.4m, C=0.15m



Flow around the u-profile



porous barriers on bridge decks

- protection vehicles from cross-wind
- prevention of sand accumulation
- ancillary structures, but strong effect on the the bridge aerodynamics

Transverse galloping

- sort of aeroelastic instability occurring when the critical value of the velocity of the air flow around bluff body is exceeded
- causing almost harmonic oscillations with high amplitude and low frequency

- studies of the proneness of the body to transverse galloping- based on quasi- steady theory

den Hartog instability criterion in the proximity of zero angle

$$\left(\frac{dC_L}{d\alpha} + C_D\right) < 0,$$

Lift coefficient (C_L); drag coefficient (C_D); impact angle (α)

$$C_D(\alpha) = \frac{2F_D(\alpha)}{\rho U^2 C}$$

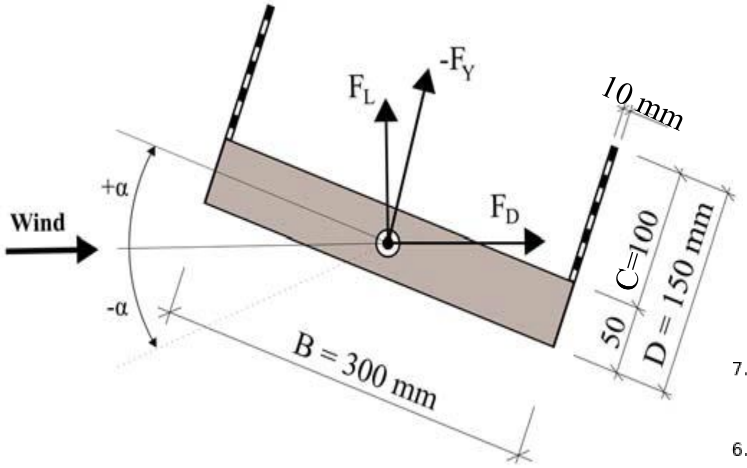
$$C_L(\alpha) = \frac{2F_L(\alpha)}{\rho U^2 C}$$

C – cross wind dimension; ρ – air density; U – air mean velocity

proneness to galloping obtained by the study of the dependence of aerodynamic forces on the angle of the attack

The geometry of wind tunnel, bluff body and computational domains

width of wind tunnel=1.9m

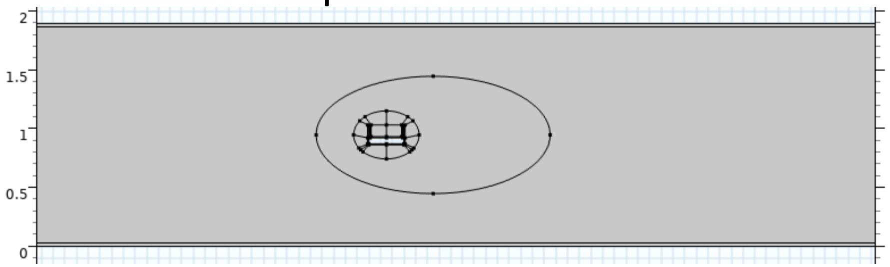


D = 15cm
B=30 cm
C=10 cm, t_b=1cm.

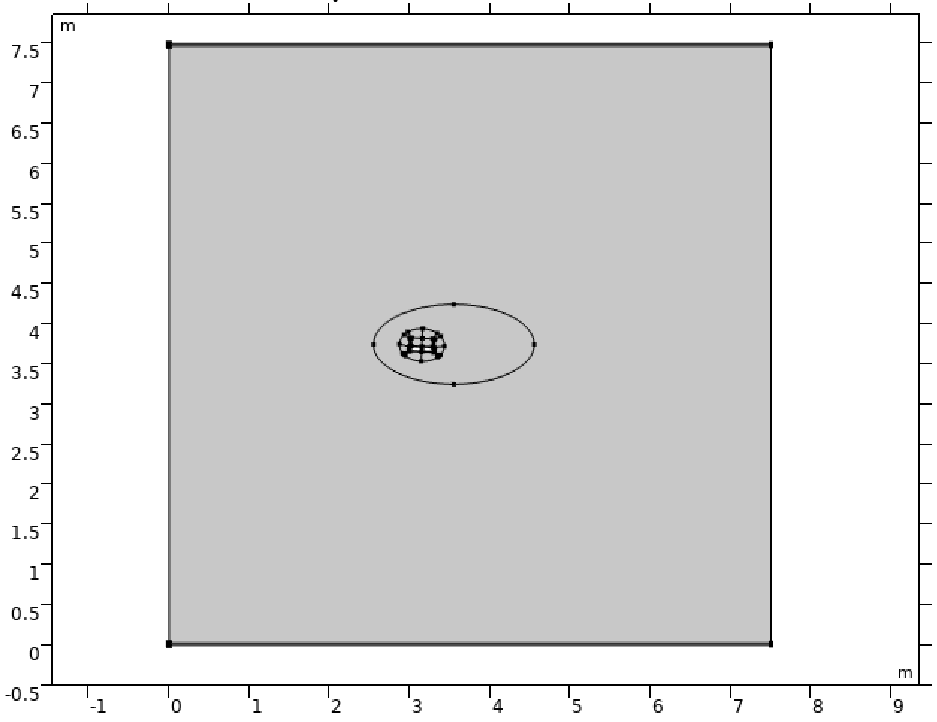
blockage ratio =8% for u-profile at zero attack angle

v=14m/s Re=1.67.10^5

width of computational domain=1.9m



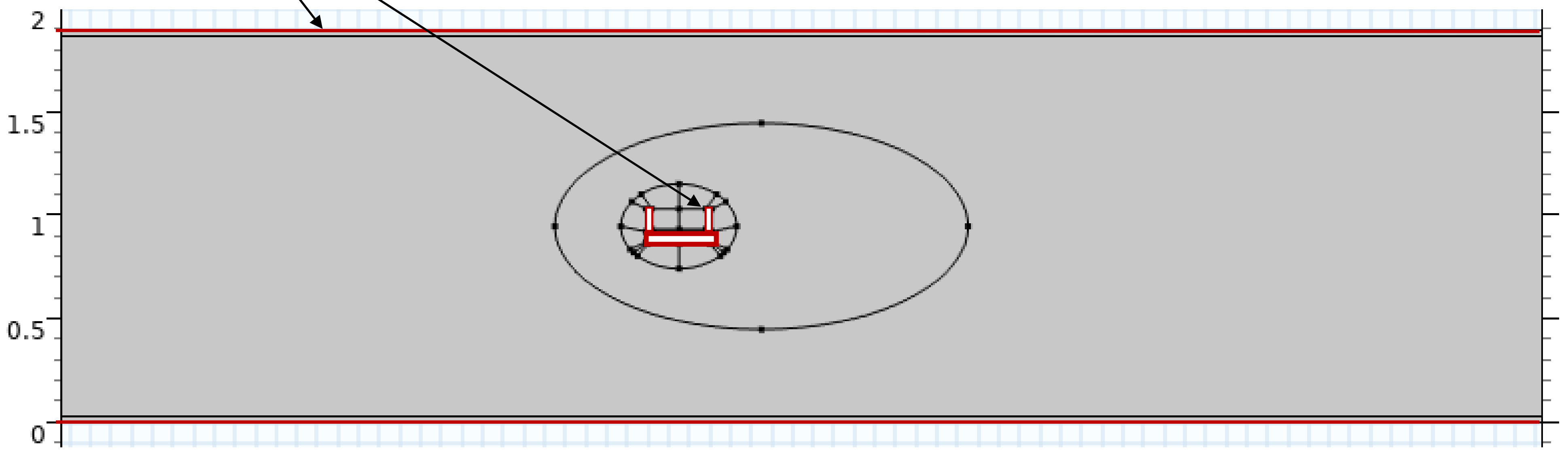
width of computational domain=7.5m



blockage ratio negligible

Setting of boundary and initial conditions

no slip condition on walls



inlet

outlet

velocity v_1=14m/s v_2=2.8m/s

turbulent intensity I=1%

α = (-12 ,12°)

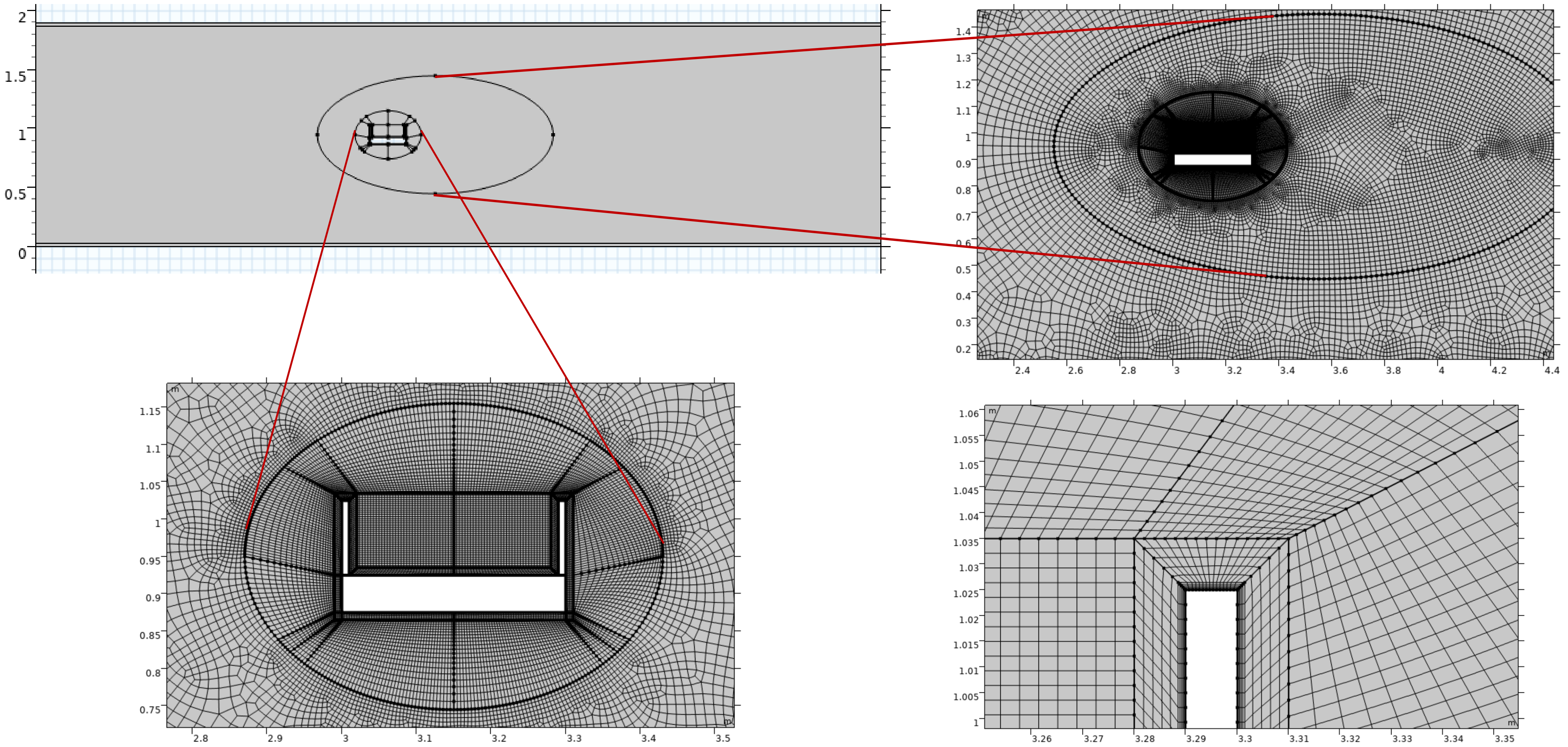
Non-porous u-profile

Porous u-profile having porosity 50%

p=0 Pa

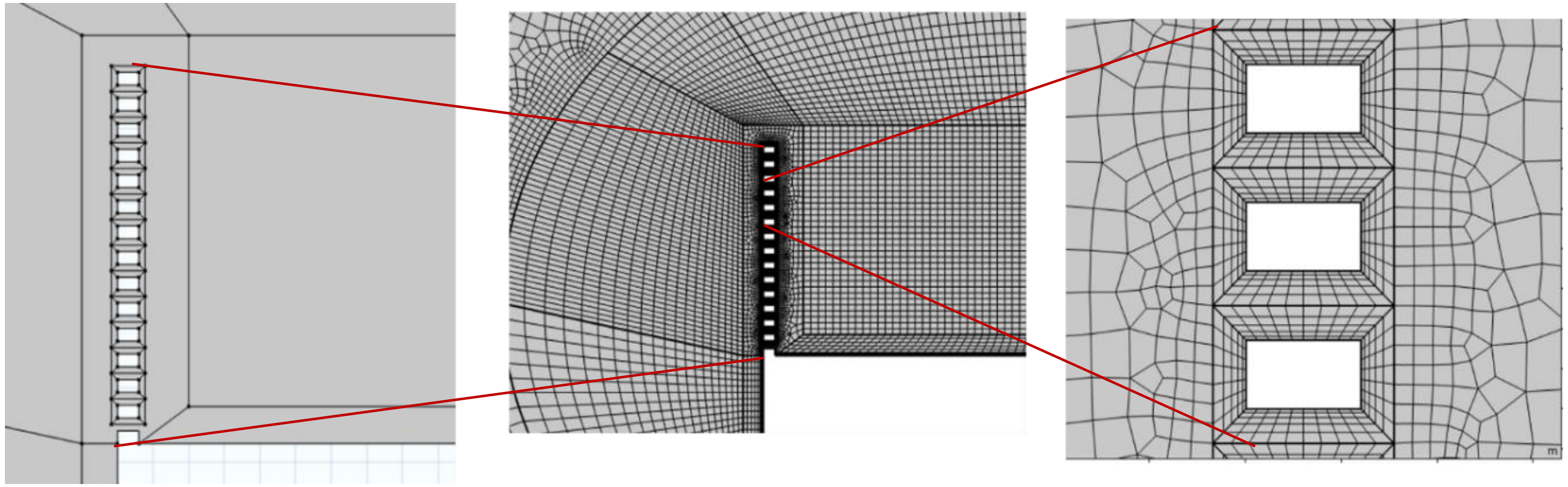
=> evaluation of mean drag and lift coefficient, fluctuating lift coefficient, Strouhal number and flow characteristics

The structure of computational mesh non-porous u-profile



The structure of computational mesh u-profile with porosity 50%

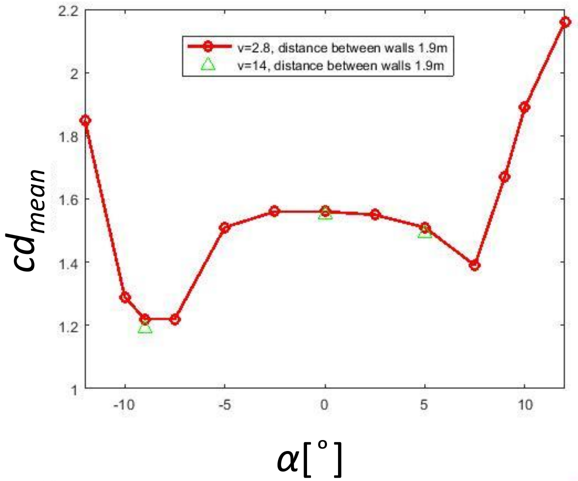
representation of porous grid -3D LES simulations –often pressure jump attempt
-2D RANS simulations- detailed geometry enabled

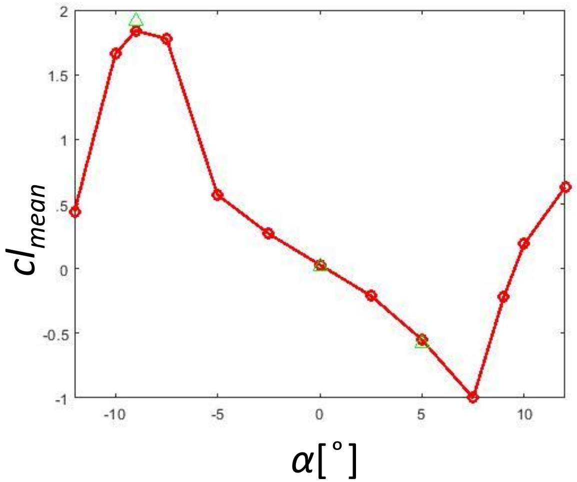


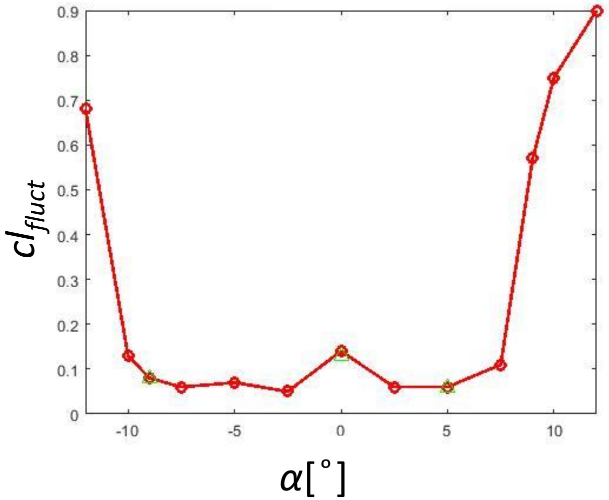
The effect of Reynolds number for non-porous u-profile

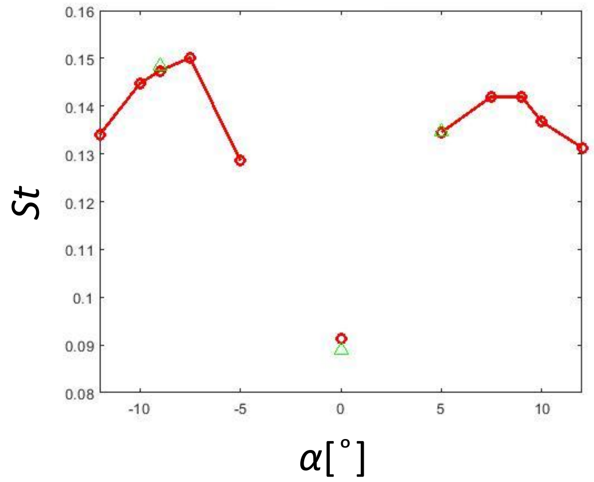
airflow velocity in wind tunnel v=14m/s (Re=1.67×10^5)

the effect of velocity decrease to v=2.8m/s (Re= 3.34×10^4)



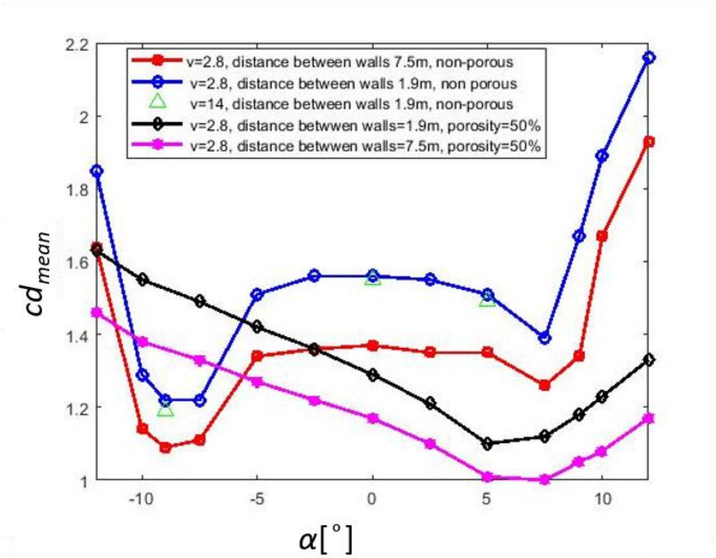




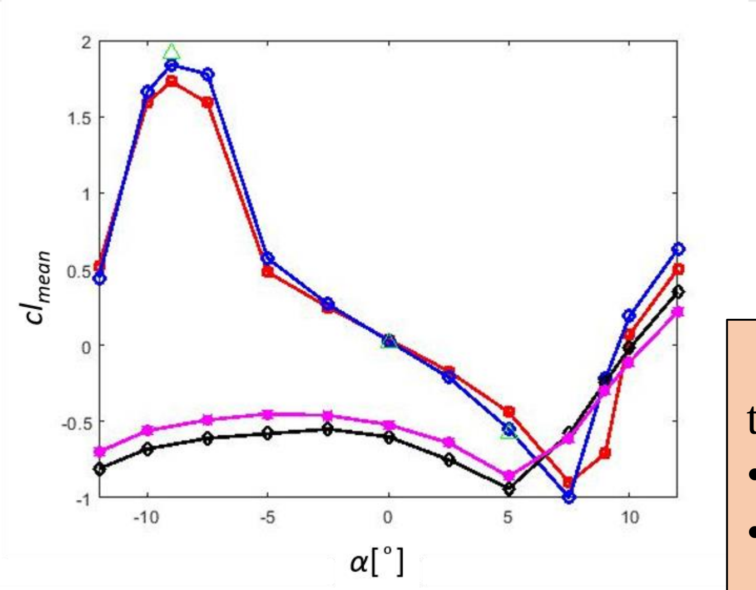


aerodynamic characteristics do not change markedly with the change of inlet velocity => v_2=2.8m/s used in further calculations

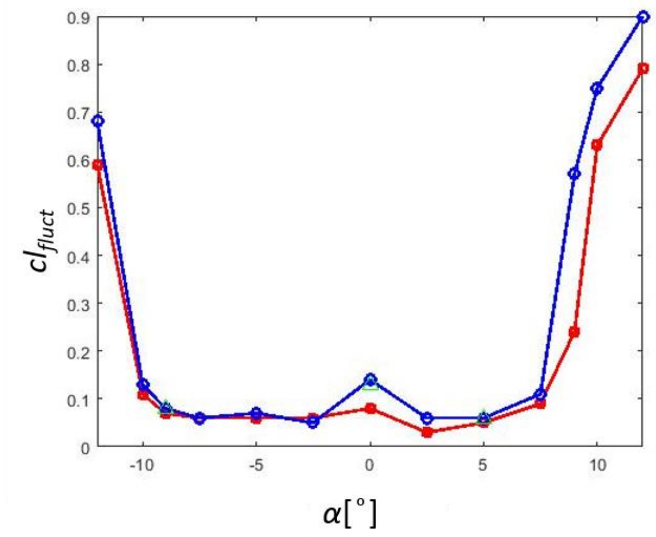
Aerodynamics characteristics of u-profile for various blockage ratios



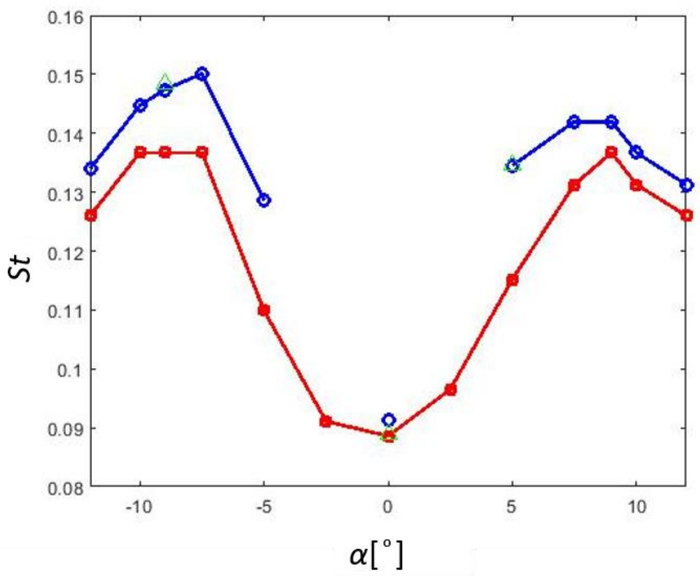
a)



b)



c)



d)

presence of confined walls in wind tunnel causes:

- increase of the mean drag coefficient
- increase of the fluctuating lift coefficient
- increase of the Strouhal number.

Conclusions

blockage effect during the airflow around non-porous and porous u-profile caused by the design of the experimental wind tunnel leads to

- increase of the mean drag coefficient
- increase the fluctuation lift coefficient
- increase of St number

obtained data will be further compared with experimental results to provide suitable corrections for the measured data.