CFD modeling of wind loading of "Domodedovo" airport structure

To calculate wind loading of "Domodedovo" airport structure CFD modeling of the wind environment around the airport "Domodedovo" construction area was made.

Full Reynolds averaged Navier–Stokes equations were used to get solution.

To define wind loading six model loading cases were considered.

The basic-model geometry is the airport model without multilevel car park. Reference velocity of the wind U_{ref}=30 m/s (at y_{ref}=30m) and four different wind directions (X, -X, Z, -Z) were considered.

Additional model case for the reference velocity of the wind U_{ref}=15 m/s (at y_{ref}=10m) and the basic wind direction (-Z) was considered. To estimate an influence of the multilevel car park special case was considered. For this case reference velocity of the wind U_{ref}=30 m/s (at y_{ref}=30m) and basic wind direction (-Z) were considered.

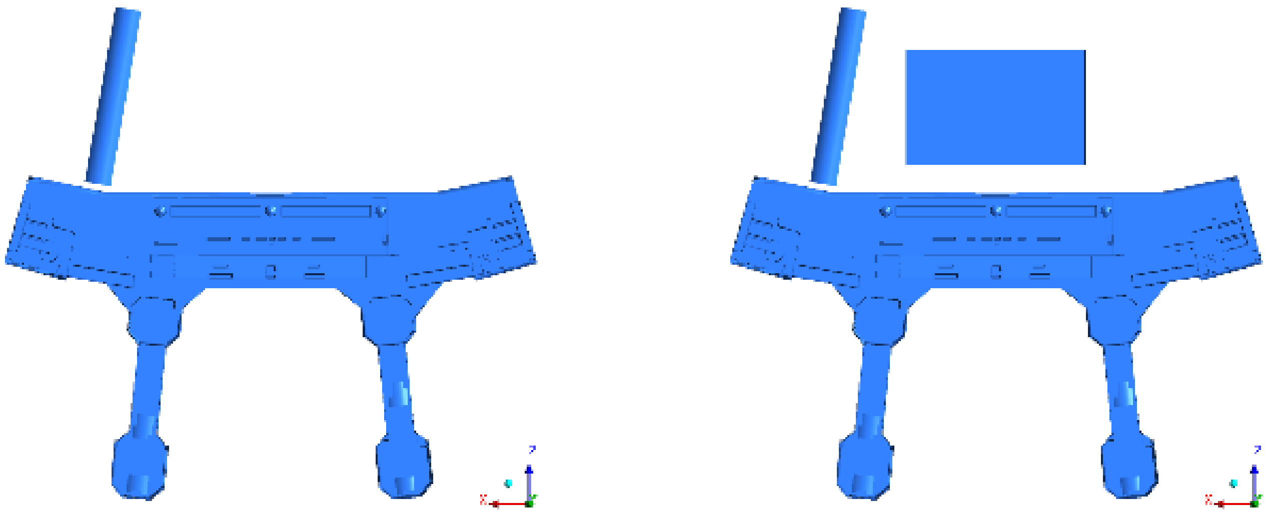

Fig. 1. Geometry models.

To setup the wind profile, the Monin–Obuhov model for neutral atmosphere stratification was used (atmosphere temperature is constant over an altitude). It is a simple model and for this model velocity profile definition can be written as: $U = \frac{u_*}{\kappa}\ln\frac{y}{y_0}$, where y_0 – parameter of the underlying roughness. To setup value u_*, measurements of the velocity wind profile within atmosphere boundary layer are used: $u_* = U_{ref}\kappa / \ln\left(y_{ref} / y_0\right)$.

The atmosphere turbulence is defined by two parameters: kinetic turbulence energy k and kinetic turbulence energy velocity dissipation ε.

For the neutral atmosphere stratification, turbulence parameters profiles can be written as: $k = \frac{u_*^2}{\sqrt{C_\mu}}$ и $\varepsilon = \frac{u_*^3}{\kappa z}$.

For Reynolds averaged Navier–Stokes equations closure, the *RNG* $k-\varepsilon$ turbulence model was used. Model geometry of the landscape within ~500m from model center takes into account characteristic features of the real earth landscape (hills, embankments, etc.), model geometry was taken out to "zero level" at radius 1000m. Model surface was divided into three types of rough surface in accordance with nature of the surrounding ground.

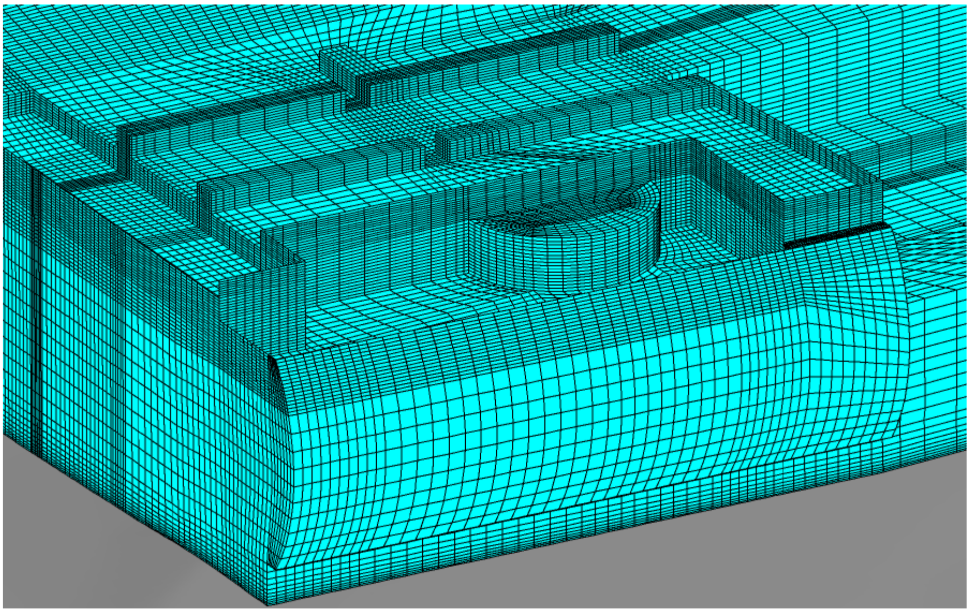

Fig. 2. Surface mesh on a model element.

Total element number $N \approx 4.5$ million. The problem is unsteady and main results of the work are pressure distributions on the model surface. The pressure was statistically averaged over solution time interval. The time interval T ~ 40-60s, during this time air masses are moved for a distance about two-three characteristic lengths of the building and, so, the resulting pressure is averaged over time that is more than characteristic life time of biggest vortices around model.

Results.

Here, some results are presented.

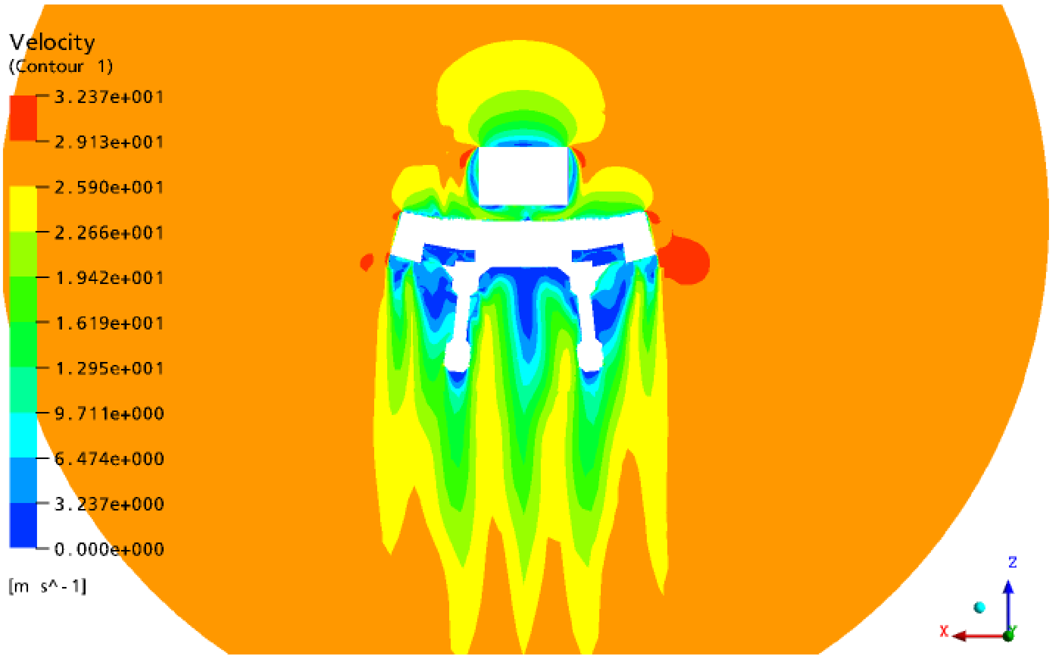

Fig. 3. Velocity distribution in slice (ZX) at Y=20m

Here is the example of an averaged pressure distribution on the building surface (model case for the reference velocity of the wind U_{ref} =15 m/s).

Pressure distributions are presented for two view variants – for negative and positive pressure (it was made for usability).

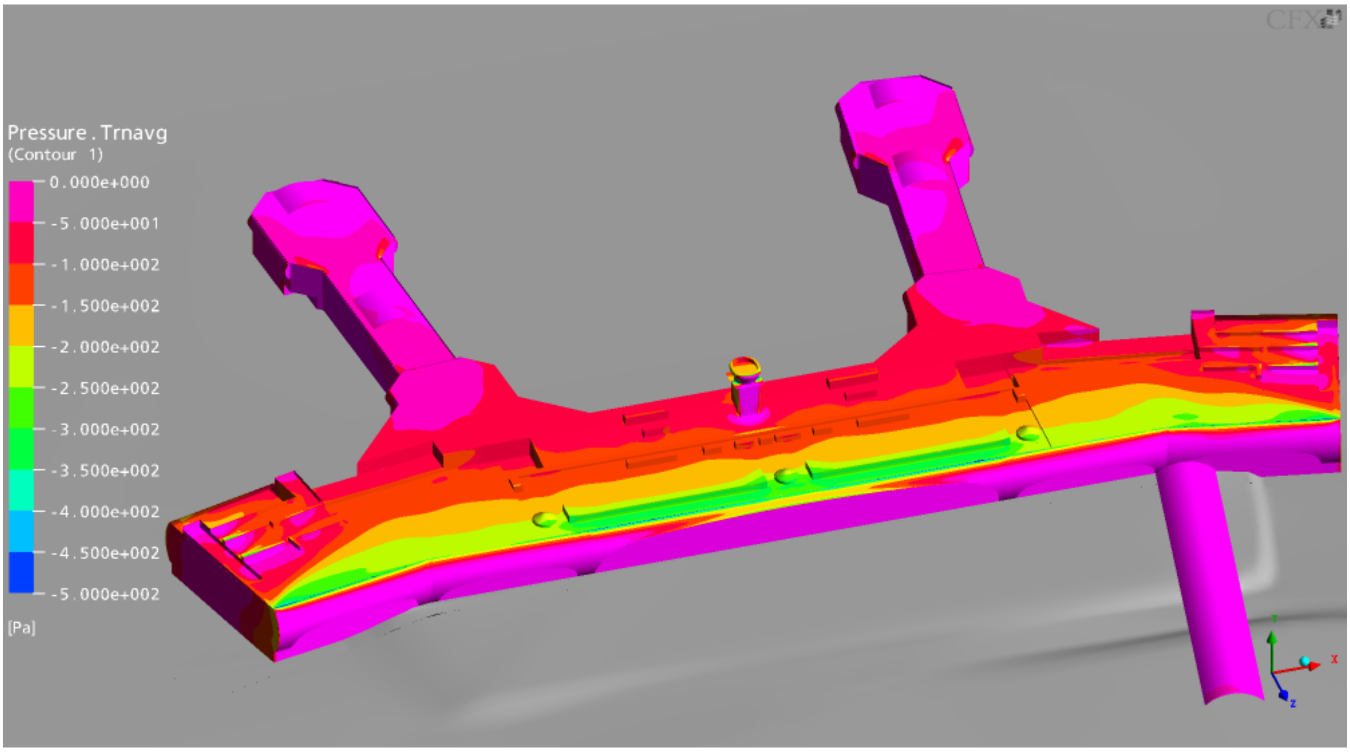

Fig. 4. Negative pressure distribution on the building surface.

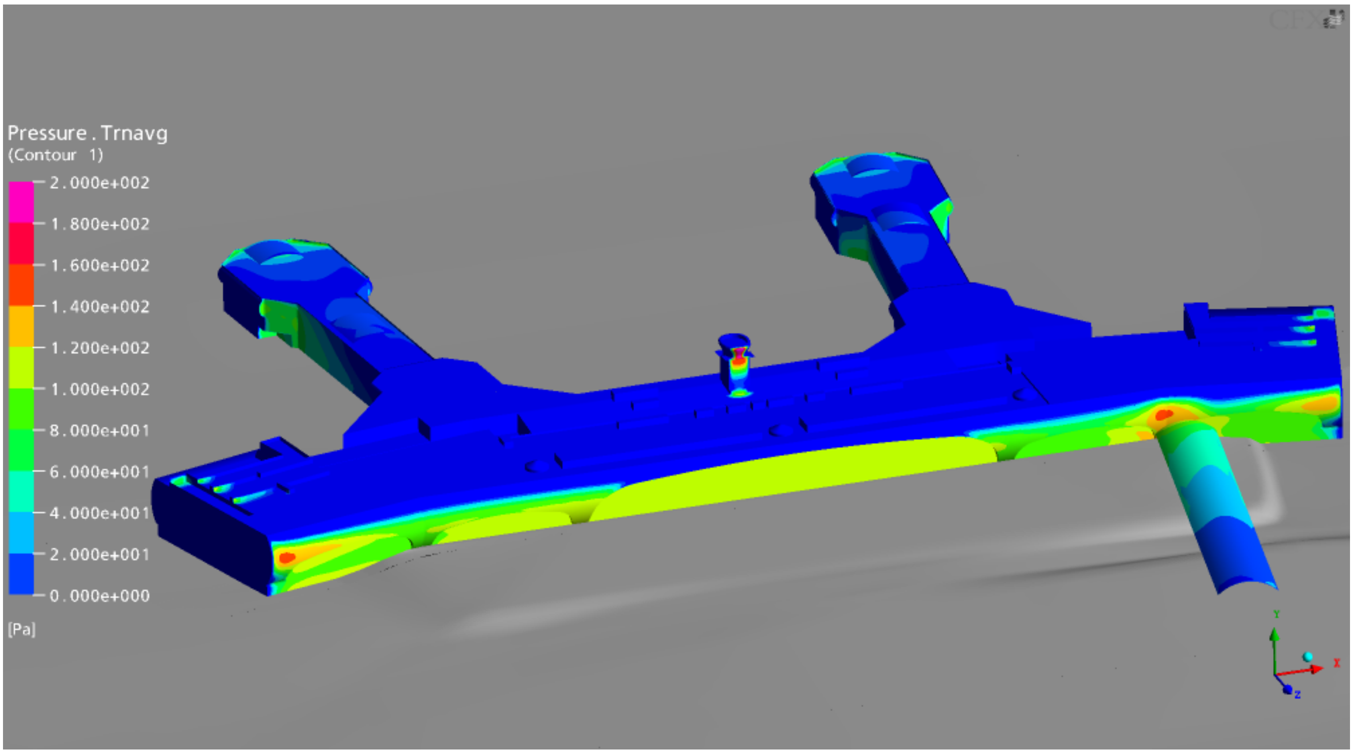

Fig. 5. Positive pressure distribution on the building surface.