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Computational Simulations of Wind Flow Patterns Around Buildings

Thursday, 6 April 2023 | Technical Topic Webinar

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Introduction - Presenter

Vijay Kumar Veera

Vijay Kumar Veera is a qualified Aerospace Engineer with over 11 years of experience in using CFD methodologies to simulate industrial and academic problems. He has obtained an M.Phil degree in Engineering from Cambridge University in UK and has M.Tech and B.Tech degrees from Indian Institute of Technology in Bombay and Madras respectively. His expertise is in capturing Fluid flow phenomena using computational methods. He has worked with major organizations in Australia and UK with Red Bull F1, Mercedes F1, Boeing, Airbus, Thales, DSTO, Fisher & Paykel some of the notable clients.

In his current role as a Unit lecturer and Course Coordinator at EIT, he has been instrumental in developing lecture materials for teaching Advanced fluid dynamics and Aerodynamics units for students pursuing Master of Mechanical Engineering. His passion is in teaching computational fluid dynamic techniques for solving real world problems, which are becoming highly popular with professional engineers wanting to advance their careers to the next level. He is a passionate educator and an advocate for using real world examples in the classroom.

Agenda

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1	Welcome and Introduction
2	Challenges in the Design of Buildings & CFD
3	CFD Simulation Methodology
4	Pressure contours
5	Velocity contours
6	Flow patterns
7	Conclusion and Q&A

CHALLENGES IN DESIGN OF BUILDINGS & CFD

- Key challenges in building design :
- Obtain the structural loads on the buildings – determine the structural stability
- Estimate cladding pressures – select appropriate materials for the facades.
- Estimate the wind comfort around the building. Identify areas that are calmer and windier.
- CFD best placed to quantify wind comfort conditions around a new building. This information can be used to guide placement of amenities around the building.
- This webinar provides an example on how to quantify flow patterns and pressures on surfaces on the building.

Slater, J.W. and Folk, T.C., 2009, September. Design and Analysis Tools for Supersonic Inlets; In Fundamental Aeronautics 2009; Technical Conference: Supersonic Program

CFD SIMULATION METHODOLOGY

Repeat the process if necessary

GEOMETRY CREATION
- **Generate the fluid domain around the building**

MESH GENERATION
- Generate a mesh that captures regions of high gradients with sufficient resolution

CASE SETUP
- Choose the appropriate turbulence model to represent flow physics
- Specify the correct boundary conditions
- Choose the solver settings necessary to run the solver.

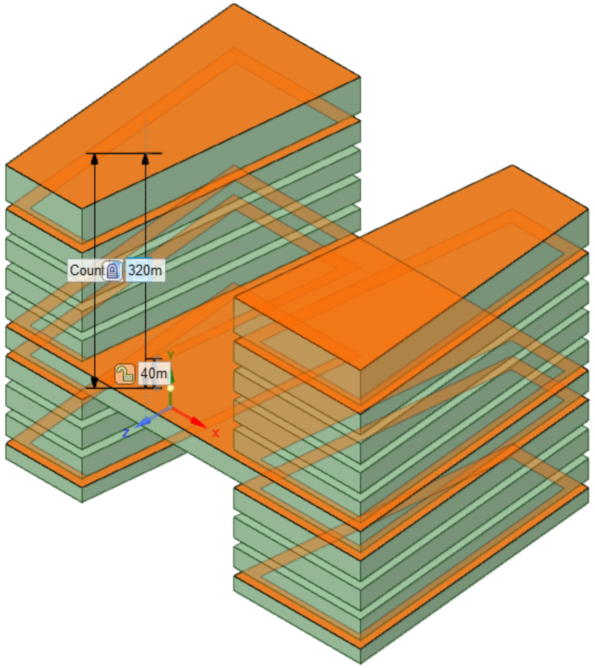
RUN SOLVER
- Solve the governing equations iteratively until the residuals drop to low values.

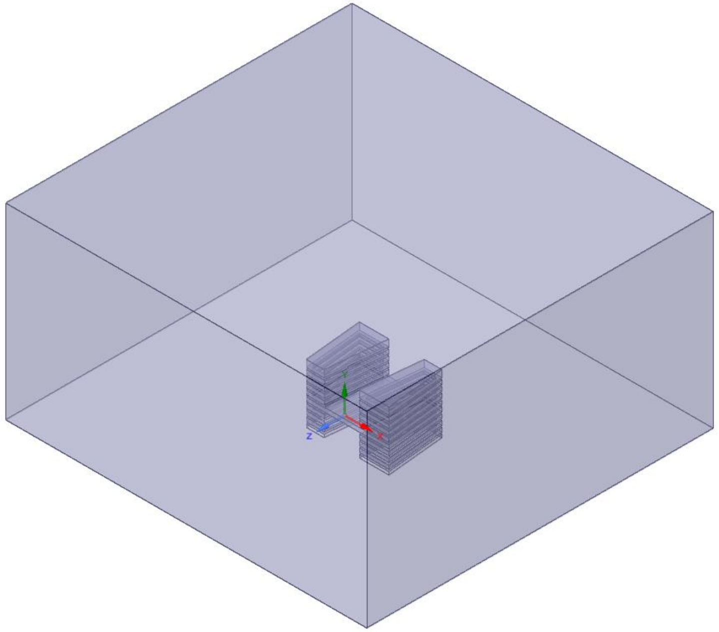
POST PROCESS
- Visualise the flow field by plotting contours, vectors, streamlines and animations.

VALIDATE RESULTS
- Compare with available experimental data to evaluate the efficacy of the CFD model.

Geometry Creation

- Example of a test building with a connected podium.
- Identify the regions where wind climate will direct usability of the space. Balconies, roofs, podium etc.
- Create a fluid volume that encompasses the building.
- Specify necessary boundary conditions. Inlet, out ground.





Software Demonstrations (screen-sharing)

Case Setup & Solver Settings

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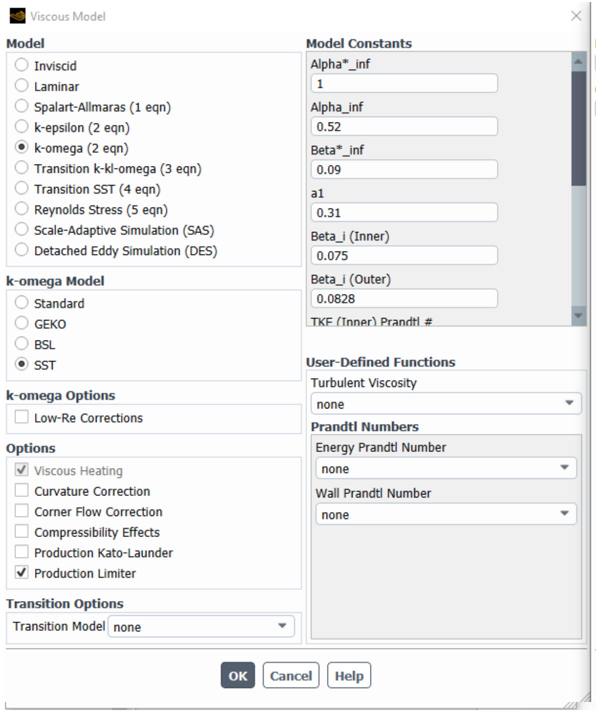
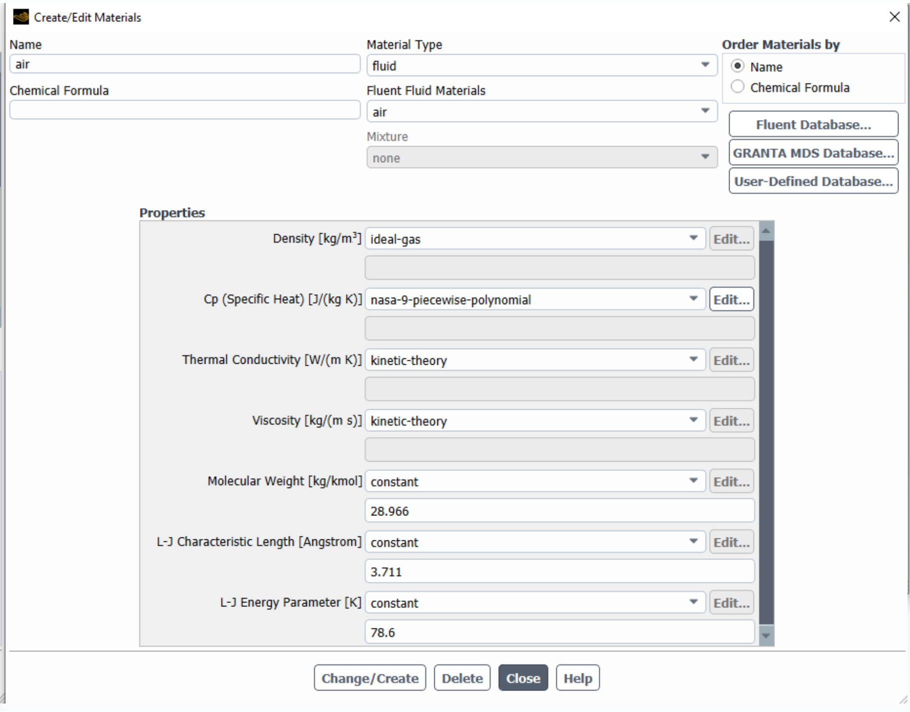
- K-ω SST turbulence model.
- Model density of air as constant .
- Set inlet velocity as 10 m/s.
- Zero pressure condition at outlet.
- No-slip condition at wall boundaries.
- Choose pressure-based coupled solver.
- Solve the flow equations with second order discretization.





Simulation Postprocessing

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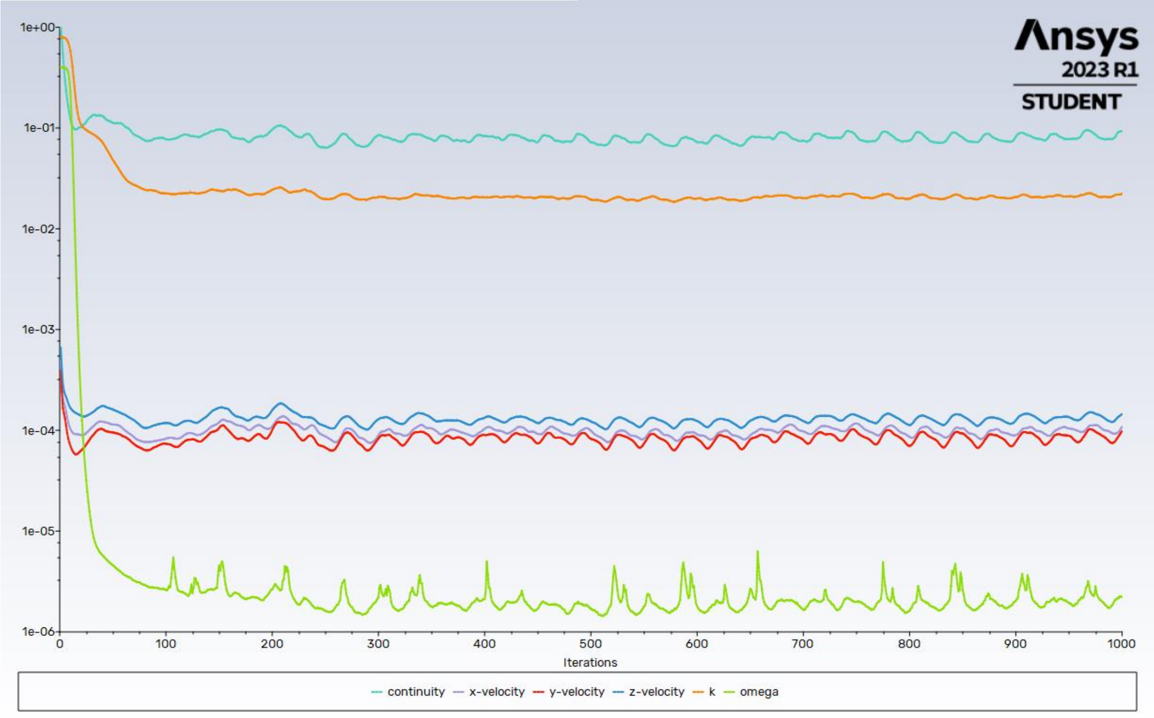
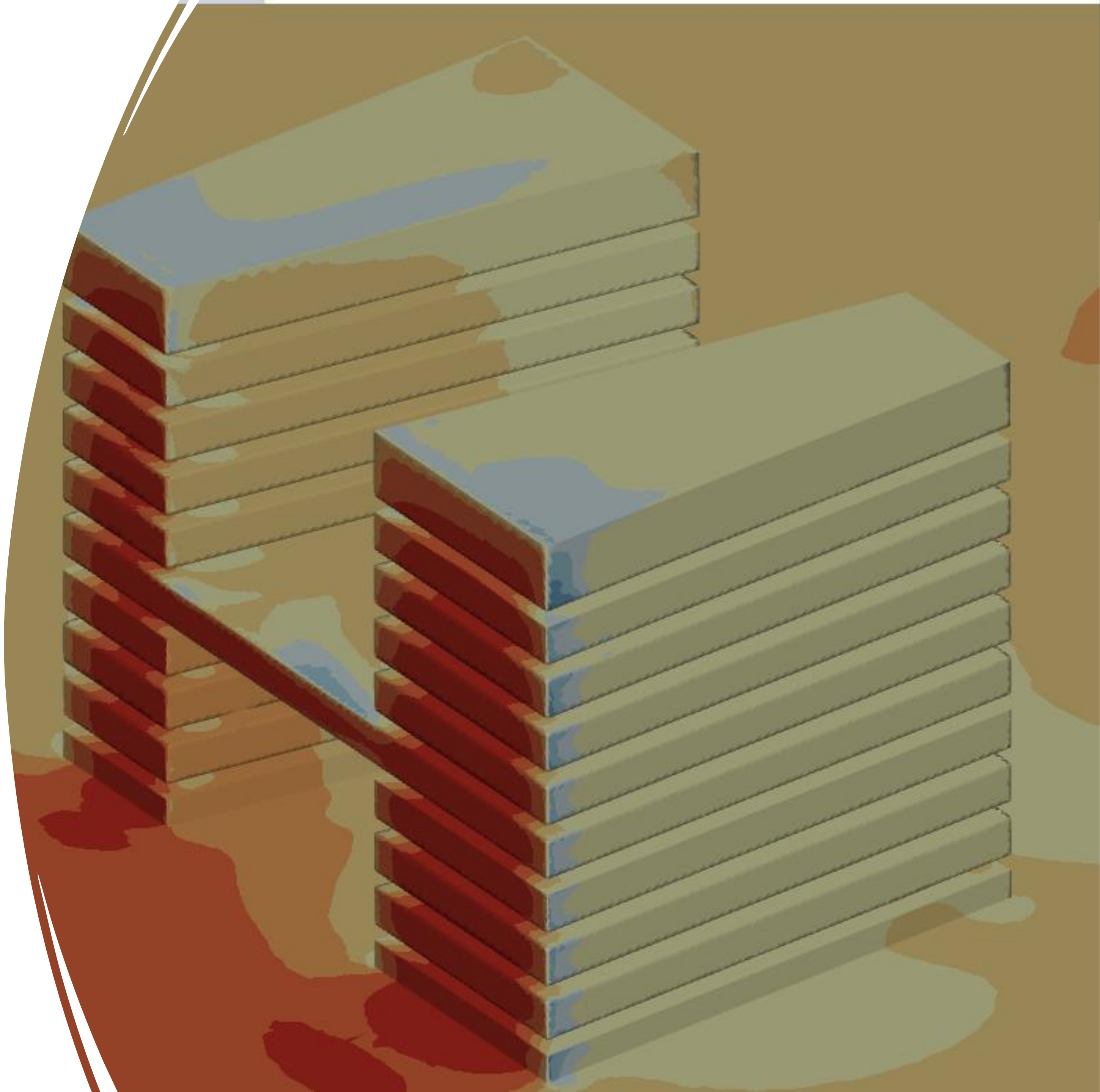


Mass Flow Rate	[kg/s]
balconies	-0
enclosure:1	-0
ground	-0
inlet	44058185
outlet	-44053326
podium	-0
roof	-0
Net	4859.1266

- Track the progress of residuals. Ideally drop by three orders of magnitude. Repeating pattern indicates recirculation zones.
- Check for mass imbalance. Ideally to be lower than 0.1% of the total inlet mass flow rate.

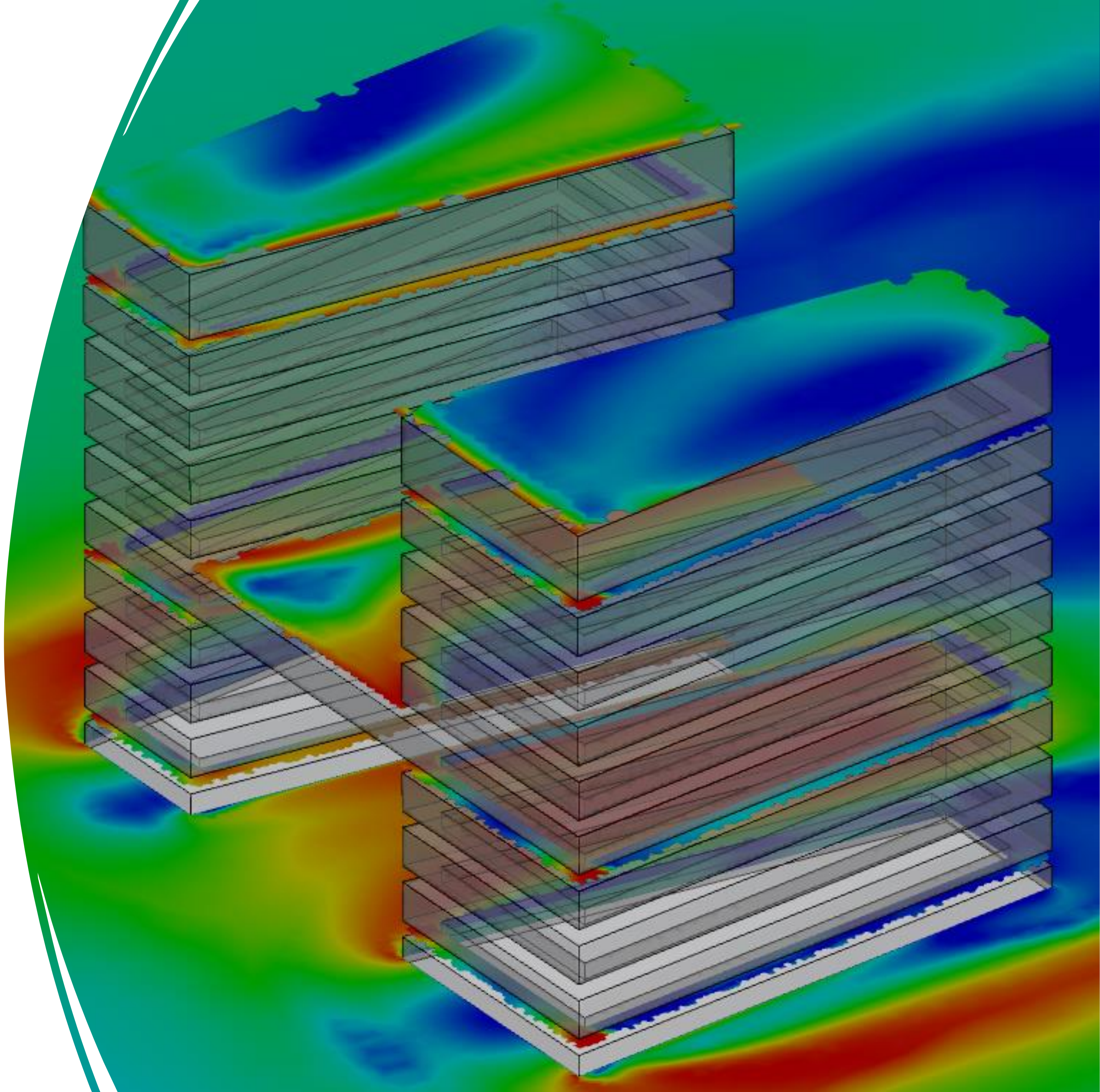
Pressure contours

- Part of building facing wind has stagnation region with high pressures.
- Corners of the building have lower pressure indicating local flow acceleration.



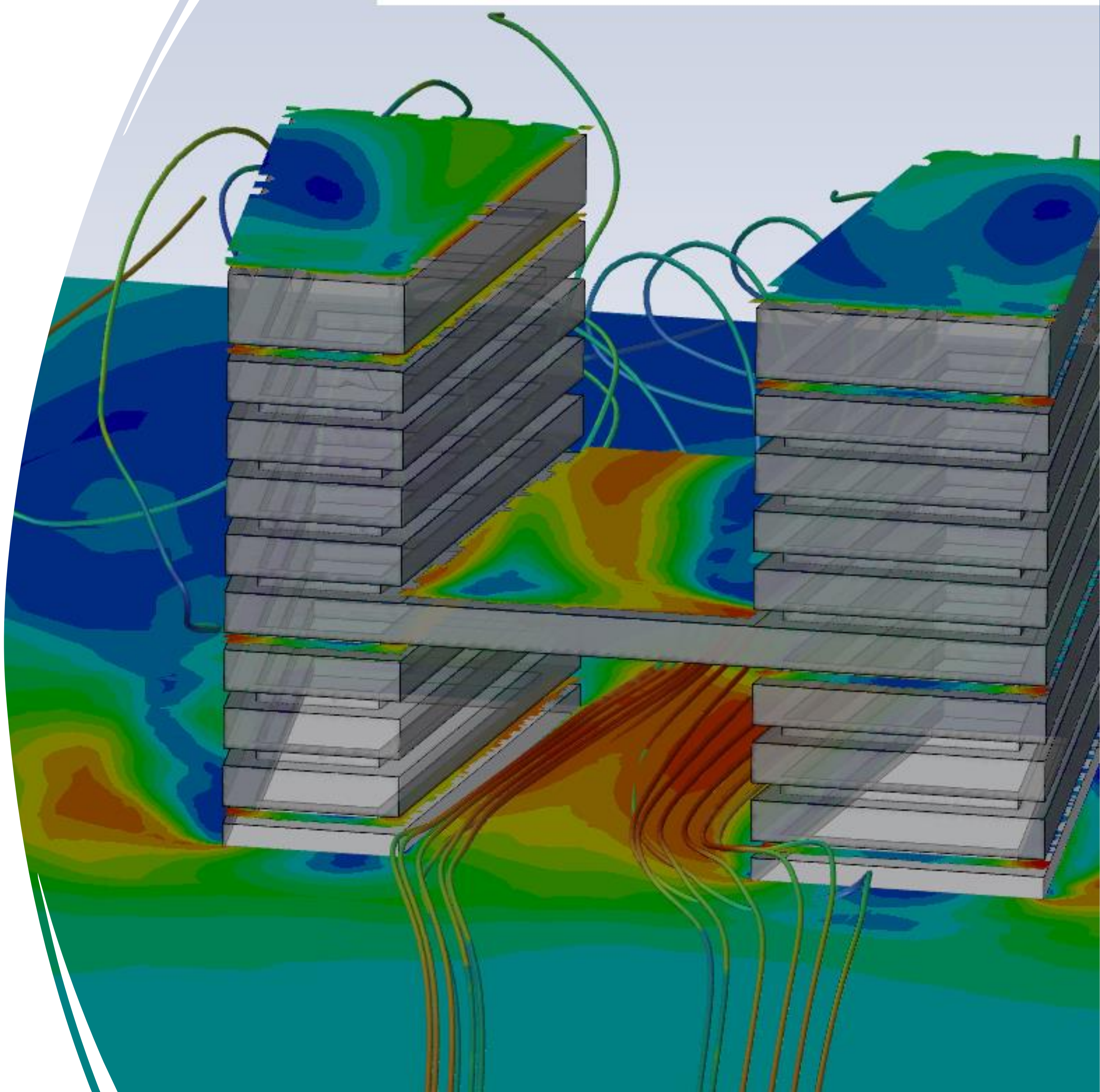
Velocity contours

- Flow field across the building varied.
- Regions in red indicate areas of flow acceleration.
- Regions in blue highlight regions of flow deceleration.



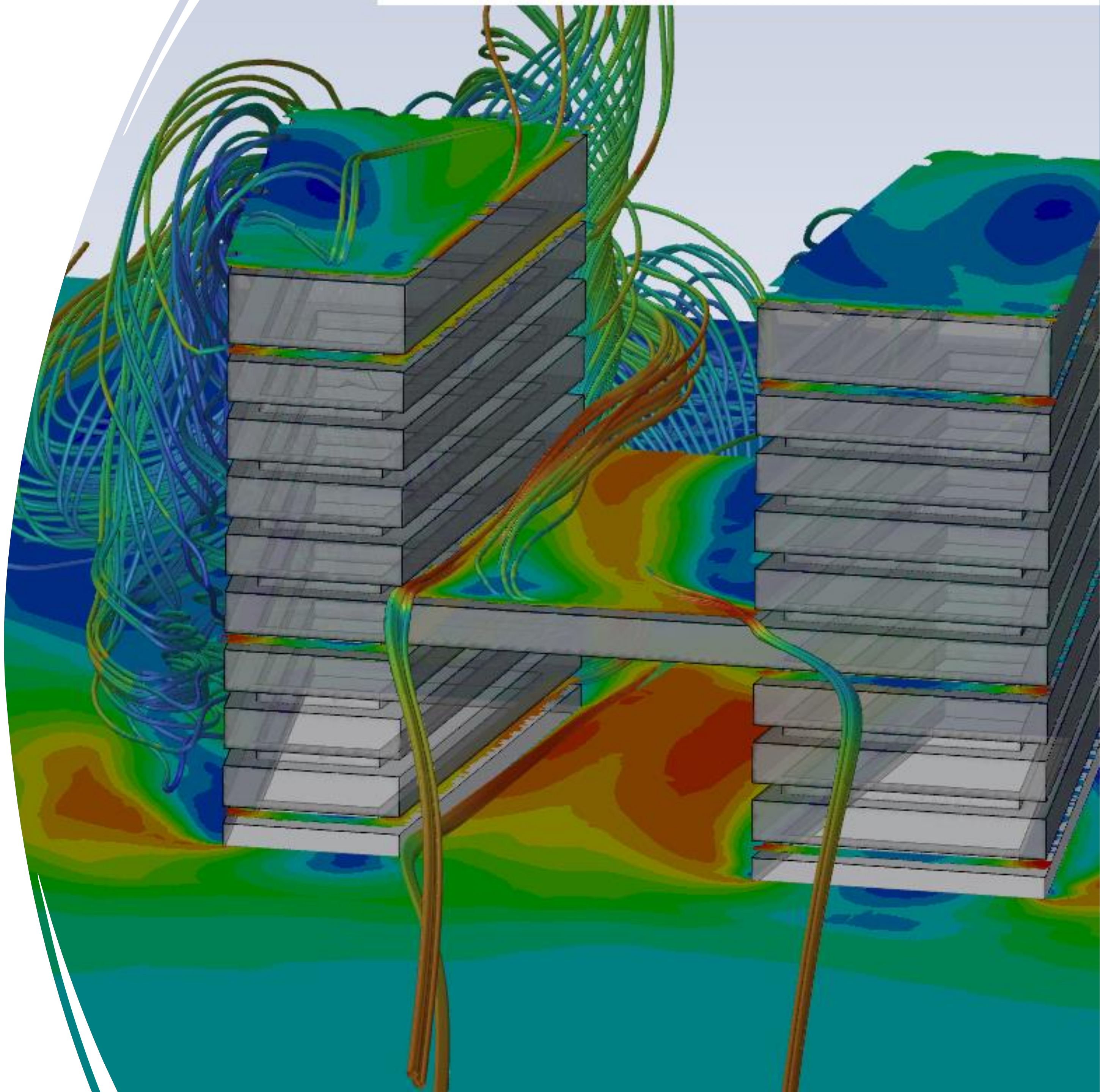
Flow patterns

- The underpass between the podium would be windy because of flow chaneling between the two buildings.
- Flow impinging onto the front of the building is channeled into this passage.
- Would be difficult for pedestrians to navigate this without mitigation measures.



Flow patterns

- Some regions of the podium are windy while others are calm.
- Flow separation beside right building creates calmer regions but pushes this flow to the left to create windy conditions there.
- This information is useful in planning activties on the podium.



SUMMARY AND CONCLUSIONS

- Brief introduction on role of CFD in predicting flow patterns around buildings.
- Visualised flow patterns in an example building.
- Understood how this information can be used to improve the design of buildings.
- Conducting such analysis up front can save significant amount of time and avoid potentially costly rework.

Hongjun, R. and Dimitri, M., 2005. Preliminary Design of a 2D Supersonic Inlet to Maximize Total Pressure Recovery; In AIAA 5th ATIO and16th Lighter-Than-Air Sys Tech. and Balloon Systems Conferences pp. 3-5.

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Q&A

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