Wind Engineering Joint Usage/Research Center
FY2023 Research Result Report

Research Field: Wind Hazard Mitigation/Wind Resistant design
Research Year: FY2023
Research Number:
Research Theme: Impact of Tornado vortex induced aerodynamic loads on structural projections in low rise buildings

Representative Researcher: Prof. Rajesh Goyal

Budget [FY2023]: 2,90,000Yen

*There is no limitation of the number of pages of this report.
*Figures can be included to the report and they can also be colored.
*Submitted reports will be uploaded to the JURC Homepage.

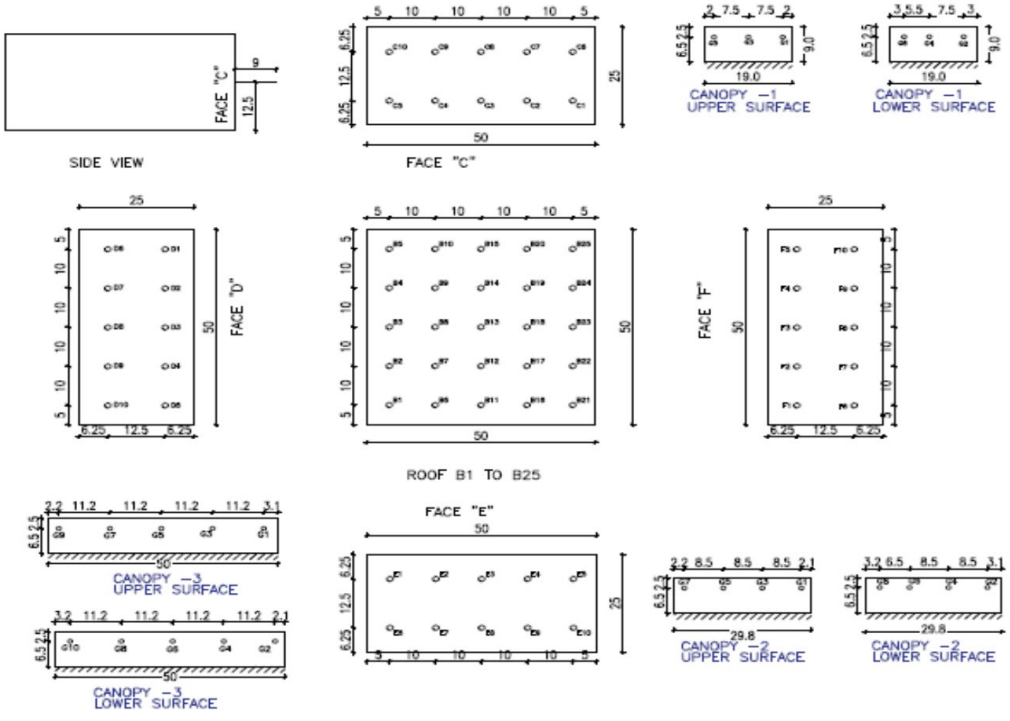
1. Research Aim

To evaluate the damage of in low rise structure and attached canopies due to aerodynamic loads caused by tornadoes like flow.

To enhance the wind pressure database of low-rise buildings with attached projections.

2. Research Method

The building models was prepared using the Perspex sheets having attached canopies of different lengths. In the present phase of study, two canopies length was prepared. One canopy of 50mm length attached to the mid height of model building. Second canopy of 29.8 mm length attached to 3/4th height of the model building from the ground. The models were prepared for measuring the surface pressure on all the surfaces on tornado simulator. For measuring the surface pressure on the surfaces of building models, pressure tapings were provided. With the help of pressure tapings, the pressure on the surfaces of building models was r e point

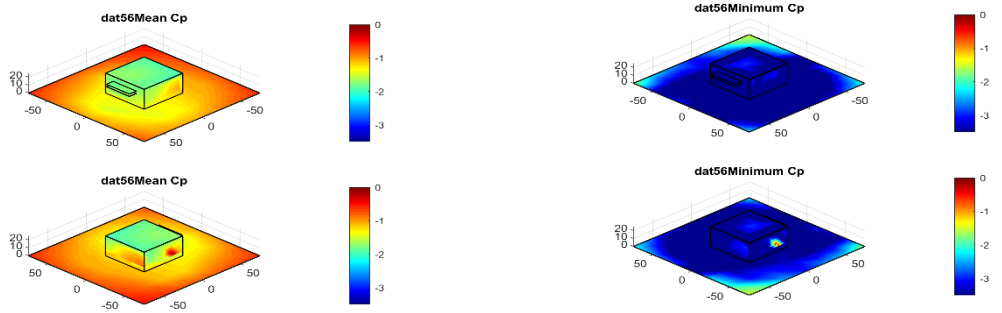


3. Research Result

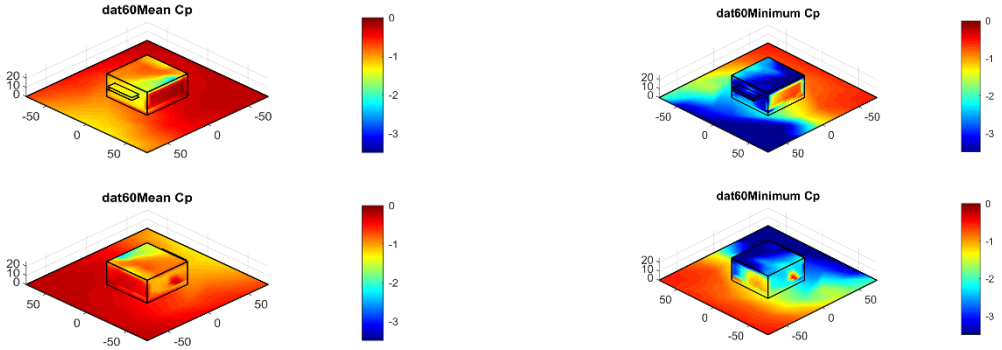
Some series of experiments were conducted with a tornado-like flow simulator in Tokyo Polytechnic University. In these experiments' temporal variations of wind pressure coefficients were measured for different distance between the centers of tornado-like flows and building models. The distances were normalized by radius of maximum wind of the swirling flows. Mean components of the pressure coefficients are shown in Figure-2. The presented components are for canopy length 29.8 mm, fixed at 3/4th height of building from the surface. The results are prepared by collection of time series data on the building model surface, canopy surface and surrounding, when tornado is approaching to the building in x and y direction and leave the building in both the directions. The distributions of the pressure coefficients were affected by separation of flows at the edge of a building model and pressure defect of the swirling flows. Some of the outcome of the study are as follows;

a) The pressure of the roof core increases as the tornado moves out of the building model core.
b) Maximum pressure coefficient on roof experienced when tornado is 30m away from the center of building.
c) Maximum negative pressure coefficient is on the upper surface of canopy and maximum negative pressure coefficient is absorbed at 10-degree slope and 20-degree slope.
d) Maximum positive pressure coefficient is on the upper surface of canopy and increases with the increase of slope.
e) Maximum negative and Maximum positive pressure coefficient increase with the increase in the length of canopy, whereas average pressure coefficient remains insignificant change

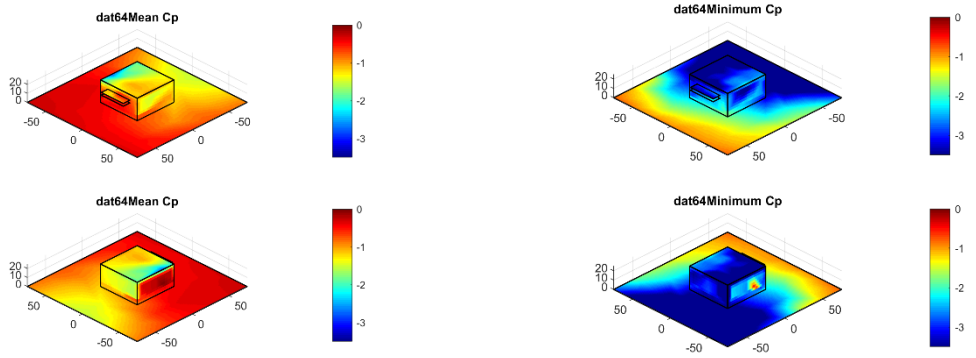
Canopy Length 30mm, Height 18.75mm Slope 0 degree, X00 and Y00



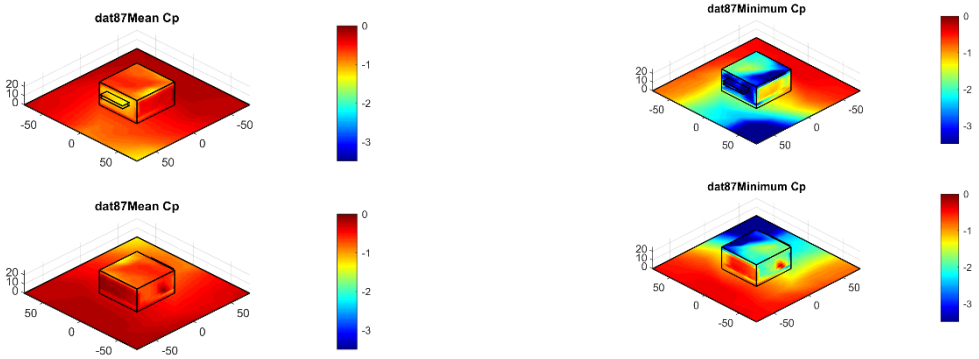
Canopy Length 30mm, Height 18.75mm Slope 0 degree, X100 and Y00



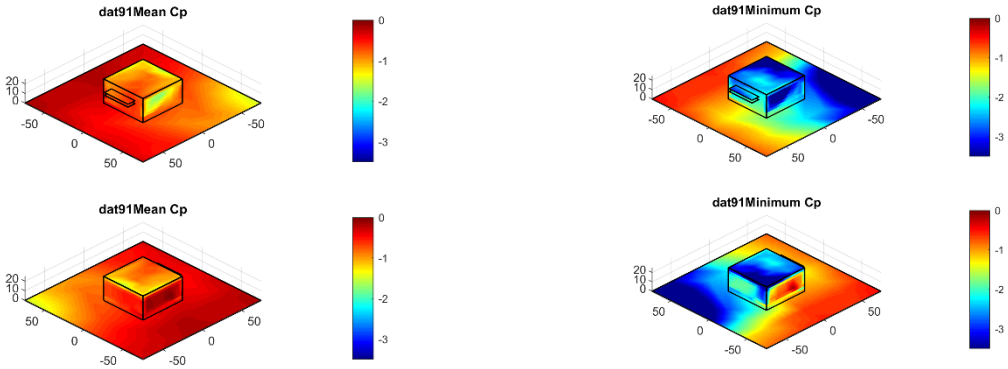
Canopy Length 30mm, Height 18.75mm Slope 0-degree, X-100 and Y00



Canopy Length 30mm, Height 18.75mm Slope 0 degree, X100 and Y75



Canopy Length 30mm, Height 18.75mm Slope 0-degree, X-100 and Y75



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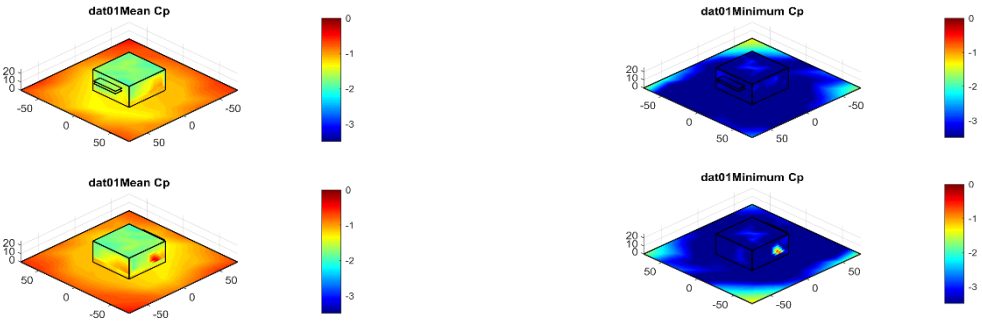
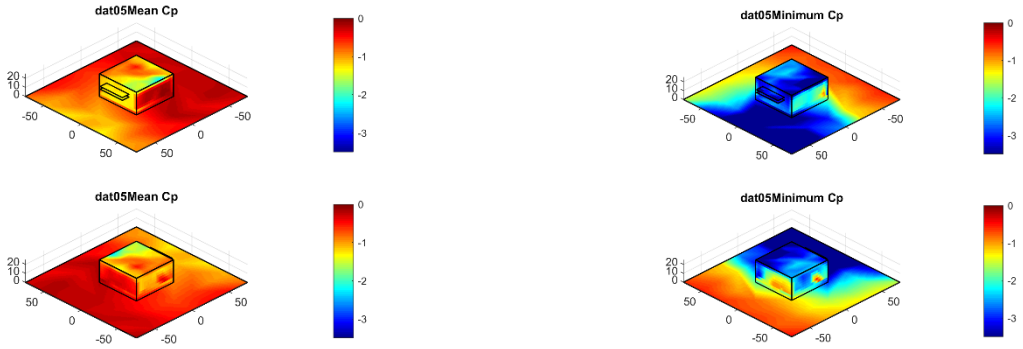
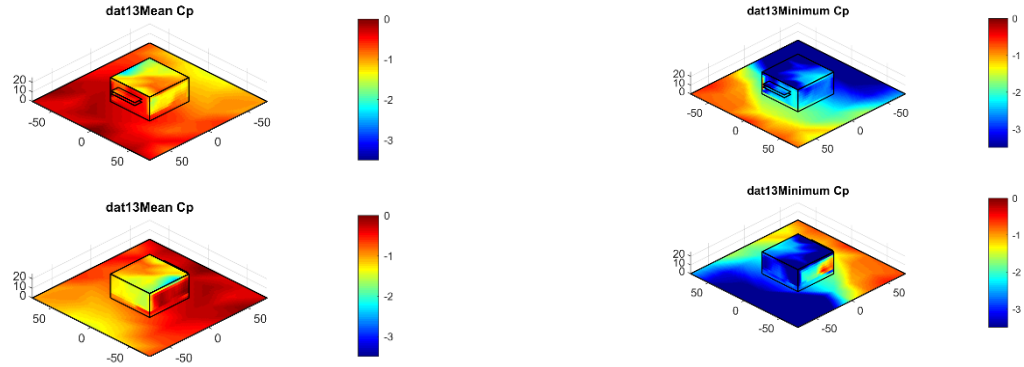


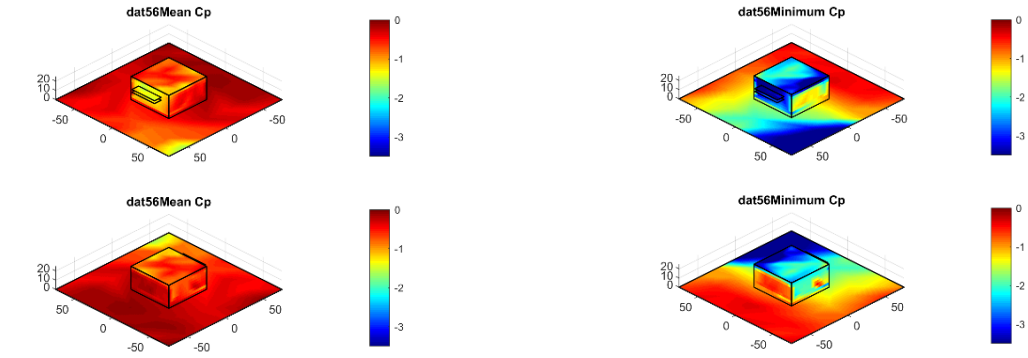
Canopy Length 30mm, Height 18.75mm Slope 10 degree, X100 and Y00



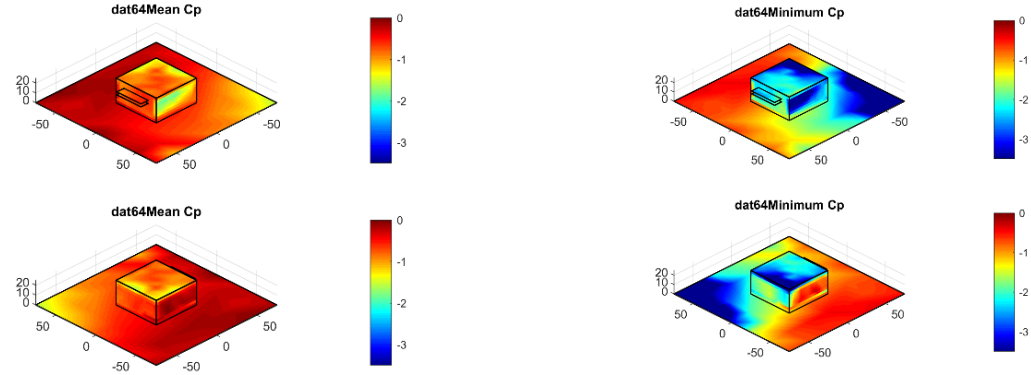
Canopy Length 30mm, Height 18.75mm Slope 10-degree, X-100 and Y00



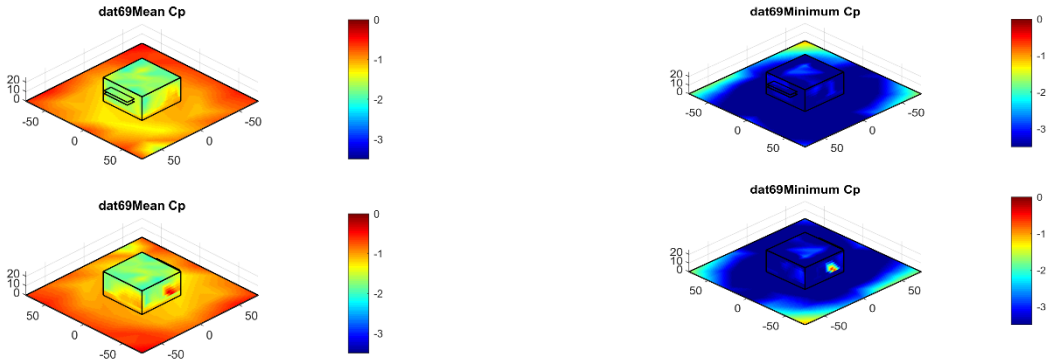
Canopy Length 30mm, Height 18.75mm Slope 10 degree, X100 and Y75



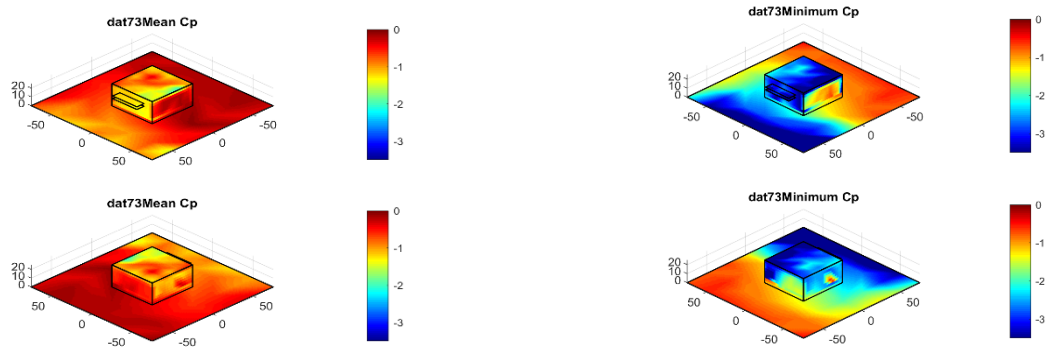
Canopy Length 30mm, Height 18.75mm Slope 10-degree, X-100 and Y75



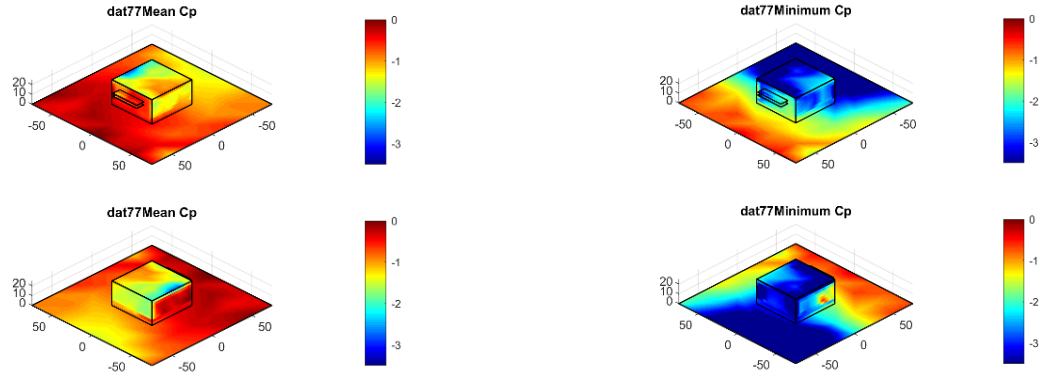
Canopy Length 30mm, Height 18.75mm Slope 20 degree, X00 and Y00



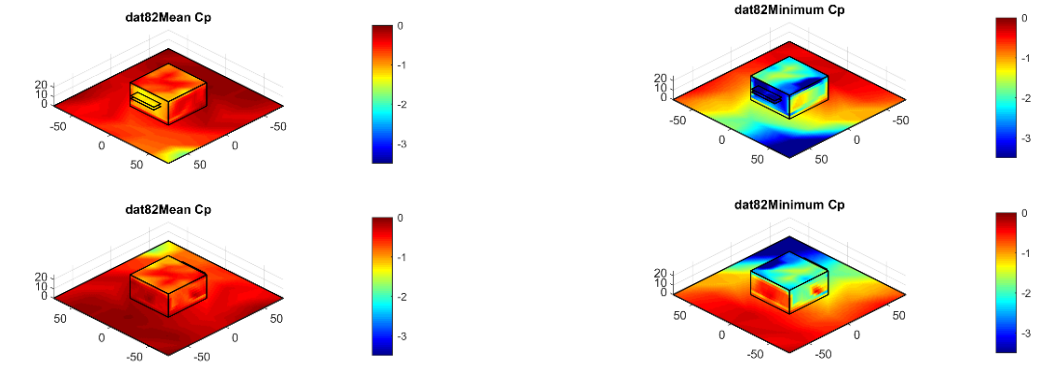
Canopy Length 30mm, Height 18.75mm Slope 20 degree, X100 and Y00



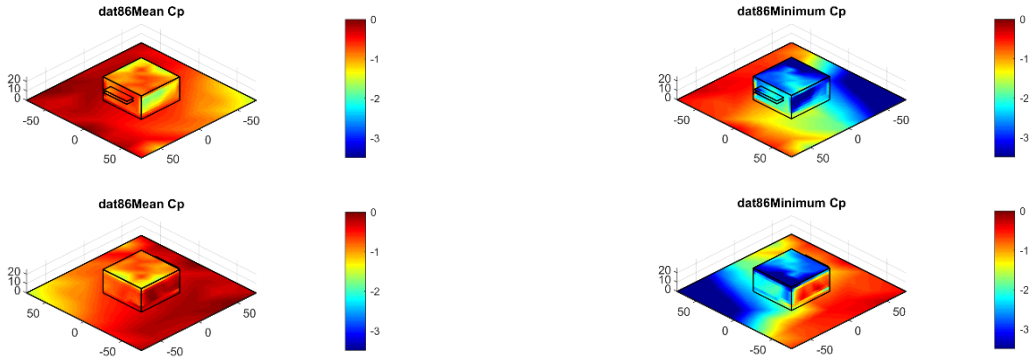
Canopy Length 30mm, Height 18.75mm Slope 20-degree, X-100 and Y00



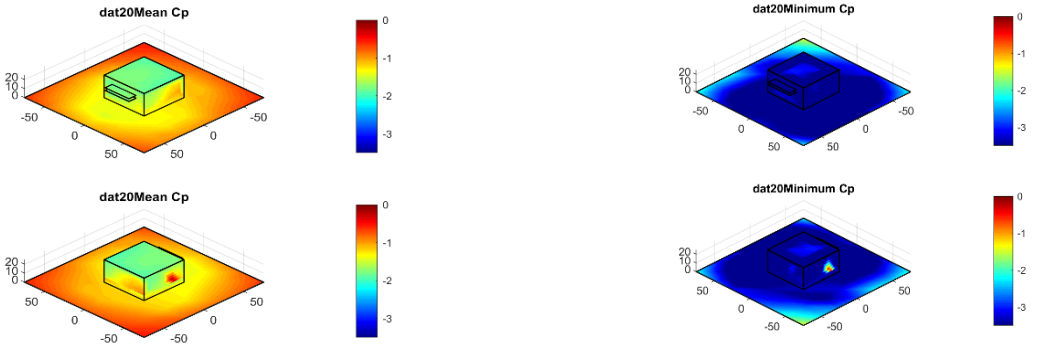
Canopy Length 30mm, Height 18.75mm Slope 20 degree, X100 and Y75



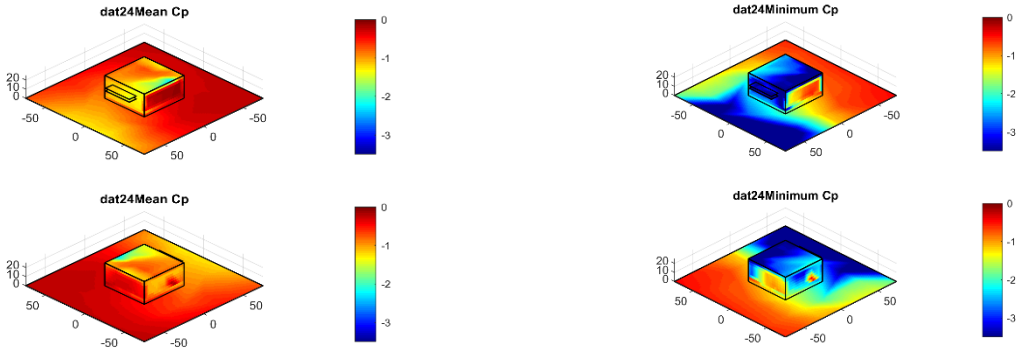
Canopy Length 30mm, Height 18.75mm Slope 20-degree, X-100 and Y75



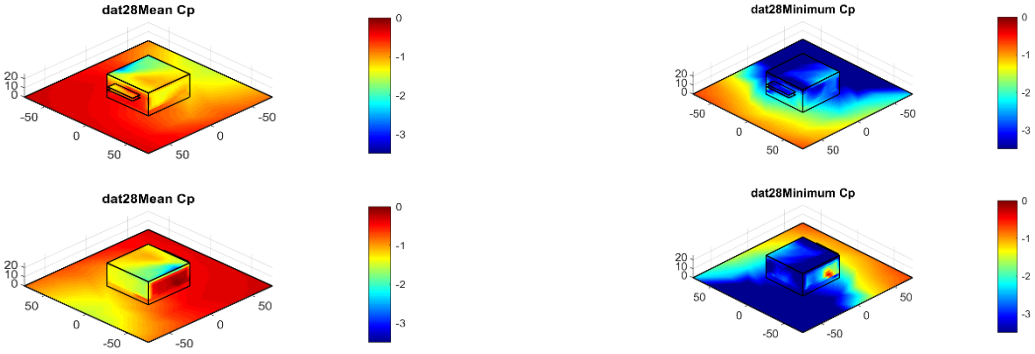
Canopy Length 30mm, Height 18.75mm Slope 30 degree, X00 and Y00



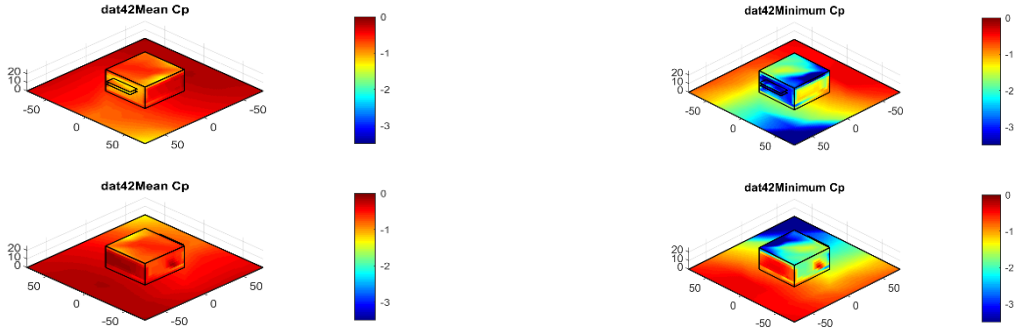
Canopy Length 30mm, Height 18.75mm Slope 30 degree, X100 and Y00



Canopy Length 30mm, Height 18.75mm Slope 30-degree, X-100 and Y00



Canopy Length 30mm, Height 18.75mm Slope 30 degree, X100 and Y75



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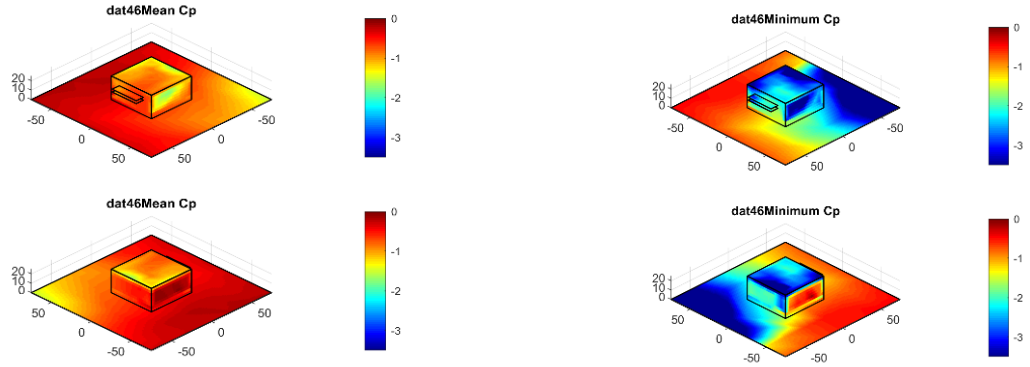

Figure-2 Mean and Minimum Cp distribution on the building model, canopy and surrounding for 29.8 mm canopy fixed at ¾ height from the surface, when tornado moves in x and y direction

4. Published Paper etc.
[Underline the representative researcher and collaborate researchers]
[Published papers]

1) Moizuddin, Mohammed, Rajesh Goyal, Nakul Gupta, and Masahiro Matsui. 2022. 29 Indian Journal of Engineering & Materials Sciences Evaluation of Wind Pressure on the Low-Rise Buildings and Surrounding Terrain under the Influence of Tornadolike Vortex Induced Aerodynamic Loads.

[Presentations at academic societies]
1. One conference paper accepted in CIB World Building Congress WBC2025: Sustainable built environment – the role of the construction community in meeting The United Nation Sustainable Development Goals (UN SDGs), Purdue University. Titled "Evaluation of Wind Pressure on the Low-Rise Buildings and Surrounding Terrain under the Influence of Tornado Like Vortex Induced Aerodynamic Loads"

[Published books]
1.
2.

[Other]
Intellectual property rights, Homepage etc.

5. Research Group

1. Representative Researcher
Rajesh Goyal, Professor, NICMAR University, Pune, India

2. Collaborate Researchers
1. Nakul Gupta, Associate Professor, GLA University, Mathura, India
2. Moizuddin, Research Scholar, RIMT University, Punjab, India
3. Masahiro Matsui, Professor, WERC, Tokyo Polytechnic University, Japan

6. Abstract (half page)

Research Theme: Impact of Tornado vortex induced aerodynamic loads on structural projections in low rise buildings
Representative Researcher (Affiliation): Prof. Rajesh Goyal, NICMAR University, Pune, India
Summary・Figures
Some series of experiments were conducted with a tornado-like flow simulator in Tokyo Polytechnic University. In these experiments' temporal variations of wind pressure coefficients were measured for different distance between the centers of tornado-like flows and building models. The distances were normalized by radius of maximum wind of the swirling flows. Mean components of the pressure coefficients are shown in Figure below. The presented components are for canopy length 29.8 mm, fixed at 3/4th height of building from the surface. The results are prepared by collection of time series data on the building model surface, canopy surface and surrounding, when tornado is approaching to the building in x and y direction and leave the building in both the directions. Some of the major outcomes of the study are;
a. Roof center experience lesser pressure coefficients compared with the roof edges when the tornado is center of model.
b. The pressure of the roof core increases as the tornado moves out of the building model core.
c. Maximum positive pressure coefficient is on the upper surface of canopy and increases with the increase of slope.
d. Maximum pressure coefficient on roof experienced when tornado is 30m away from the center of building.
e. Maximum negative pressure coefficient is absorbed at 10-degree slope and 20-degree slope.