# Wind Engineering Joint Usage/Research Center
# FY2022 Research Result Report

Research Field: Wind Hazard Mitigation/Wind Resistant design
Research Year: FY2022
Research Number: 22222005
Research Theme: Impact of Tornado vortex induced aerodynamic loads on structural projections in low rise buildings

Representative Researcher:
Prof. Rajesh Goyal

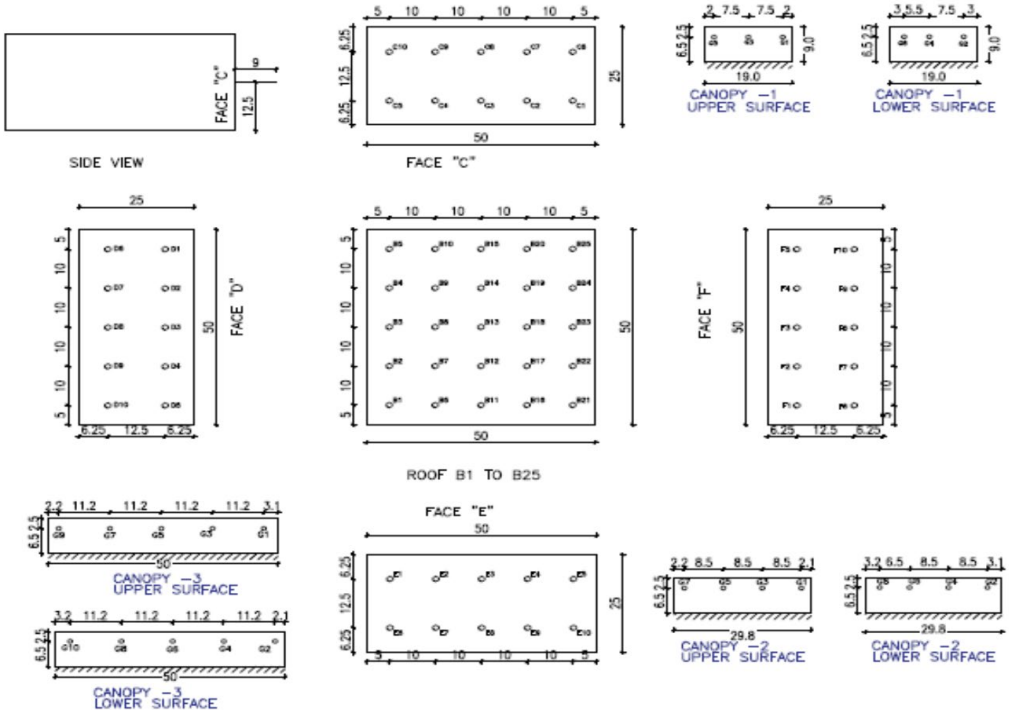
Budget [FY2022]: 2,90,000Yen

*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 on the attached canopies in low rise structure due to aerodynamic loads caused by tornadoes.
   To enhance the wind pressure database of low-rise buildings with attached projections.

2. Research Method

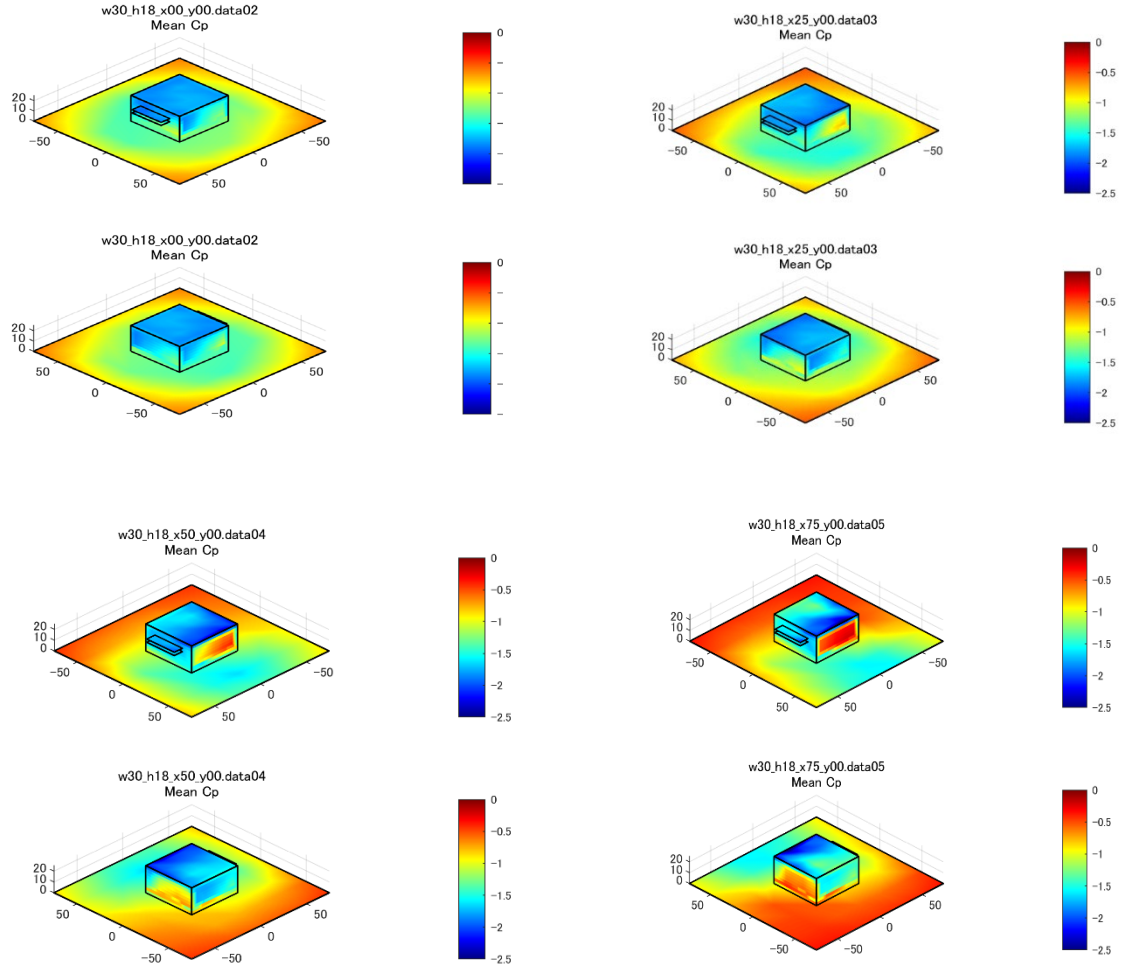
The building models was prepared using the Perspex sheets having attached canopies of different lengths. In the present phase of study, two canopies length was prepared. One canopy of 50mm length attached to the mid height of model building. Second canopy of 29.8 mm length attached to 3/4$^{th}$ height 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 measured using the pressure measuring instruments. Exploded view of the pressure points on model surface and canopies are shown in Figure-1.



## 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 3/4$^{th}$ 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. 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 pressure coefficient on roof experienced when tornado is 30m away from the center of building.
d. 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.
e. Maximum positive pressure coefficient is on the upper surface of canopy and increases with the increase of slope.
f. Maximum negative and Maximum positive pressure coefficient increase with the increase in the length of canopy, whereas average pressure coefficient remains insignificant change



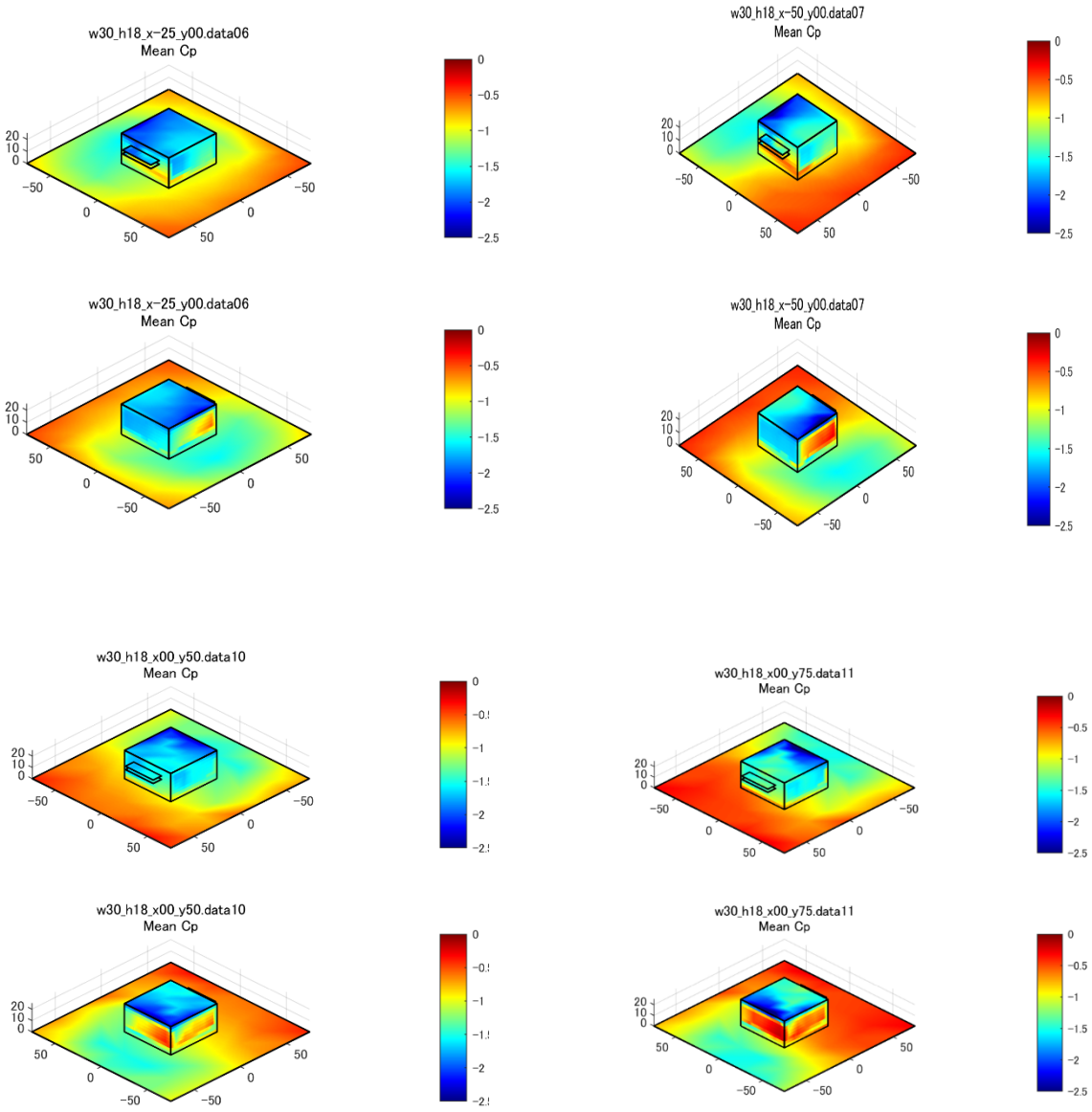



Figure-2 Mean Cp distribution on the building model, canopy and surrounding for 29.8 mm canopy fixed at ¾ height from the surface, when tornado moves in x and y direction

4. Published Paper etc.

1. Mohammed Moizuddin, Rajesh Goyal and Masahiro Matsui, "Estimation of Critical Wind Loads of the Attached Canopies of Low-Rise Buildings Under the Influence of Tornado like Wind Flow" presented at National Conference on Wind Engineering, BITS-Hyderabad, India during March 3-4, 2023

[Presentations at academic societies]

1. Rajesh Goyal, Mohammed Moizuddin, Masahiro Matsui, "Evaluation of wind pressure on low-rise building projections and surrounding terrain under the influence of tornado like flow" accepted for presentation during 16th International Conference on Wind Engineering at Florene, Italy, August 2023.

[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. Moizuddin, Research Scholar, RIMT University, Punjab, India
2. 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 3/4$^{th}$ 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 outcome 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.