Wind Engineering Joint Usage/Research Center
FY2018 Research Result Report

Research Field: Wind Hazard Mitigation
Research Year: FY2018
Research Number: 182003
Research Theme: Impact of Tornado Vortex Induced Aerodynamic Loads on Structural Projections in Low Rise Buildings

Representative Researcher: Prof. (Dr.) Rajesh Goyal, NICMAR, India

Budget [FY2018]: 150,000 Yen

*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
   a) To evaluate the damage of projections in low rise structure due to aerodynamic loads caused by tornadoes.
   b) To enhance the wind pressure database of low-rise buildings with attached projections.

2. Research Method

The building models prepared using the Perspex sheets having attached canopies. The models were prepared for measuring the surface pressure on all the surfaces. 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. It was proposed to measure the fluctuating pressure on the surfaces caused by aerodynamic wind loads. The measured pressures then be analysed and compared with the available recommendation of wind codes and other researchers (if available).

It was proposed to conduct surface pressure measurement on the models of flat roof building with attached canopy, under the influence of tornado vortex. The prototype was small industrial building with flat roof having dimensions L = 20 m, B= 20 m and height H= 10 m. Building entrance was attached with a cantilever canopy slab of 8 m to 16m length and 3.6 m width attached at the height of building 10m. Canopy slope was considered as 0°. The schematic diagram of the prototype building is shown in Fig.1

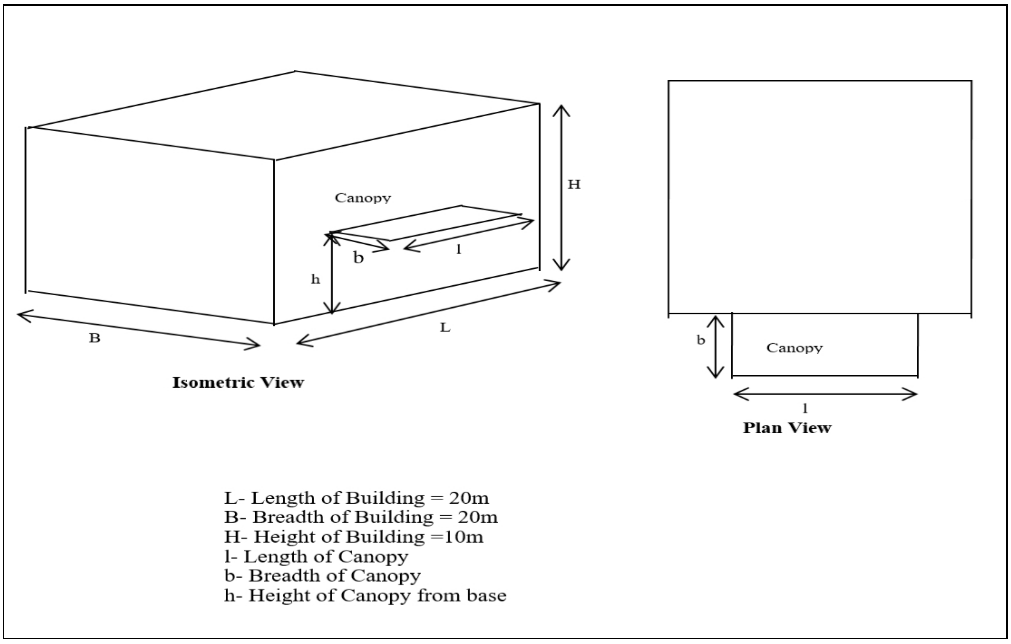


Figure 1 – Schematic diagram of prototype building

Model Size, Scale and Parameters of Canopy to be studied

It was proposed to consider as geometric model of 1:400. Table-1 presents the size of porotype and their corresponding sizes of model. Canopy parameters like height of canopy, width of canopy and slope of canopy were proposed to be studied. Table-2 presents number of pressure points fixed on different surfaces of building model.

Table-1 Size of prototype and model as per geometric scale of 1:400

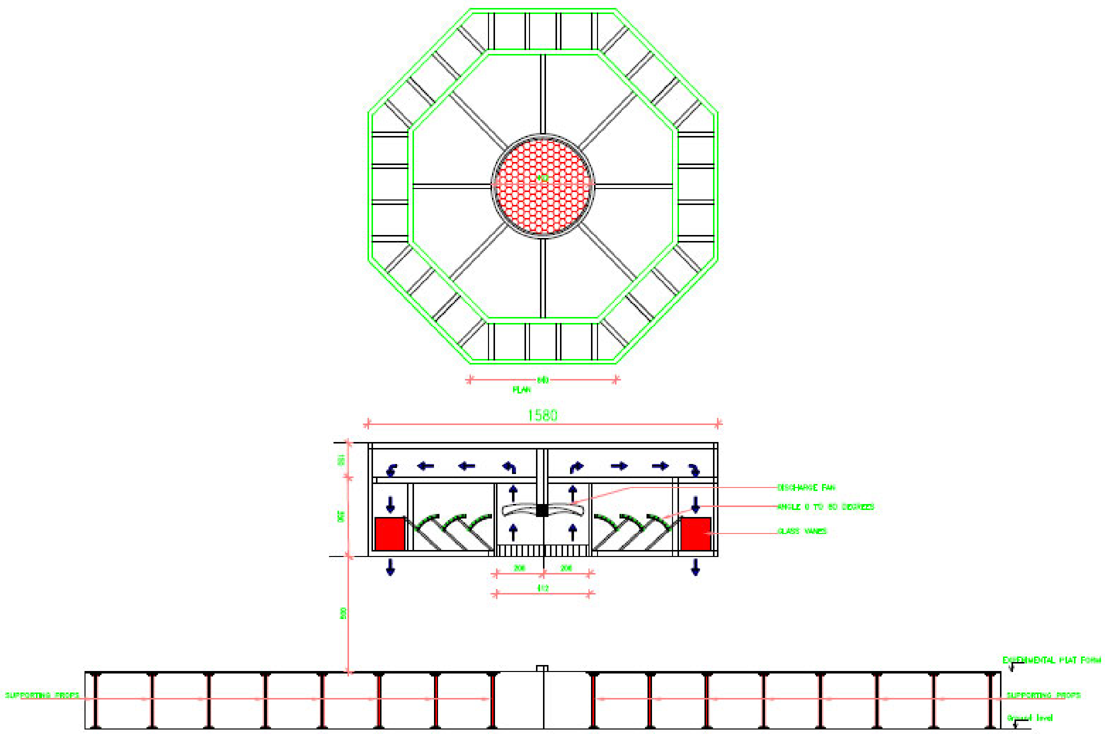
Item	Prototype (m)	Model (mm)	Remarks
Length	20m	50mm	
Breadth	20m	50mm	
Height of building	10m	25mm	
Height Of canopy	3.75m,5.00m,6.25m	9.4mm, 12.5mm, 15.6mm	
Width of canopy	3.6m	9mm	
Length of canopy	8m, 12m,16m	20mm, 30mm,40mm	
Slope of canopy	0° - 30°		At an interval of 10°
F1 Tornado path width (core radii)	16–36 m	40mm -90mm	Actual F1 radius range from (16m to 50)

Table-2 Pressure Measuring points

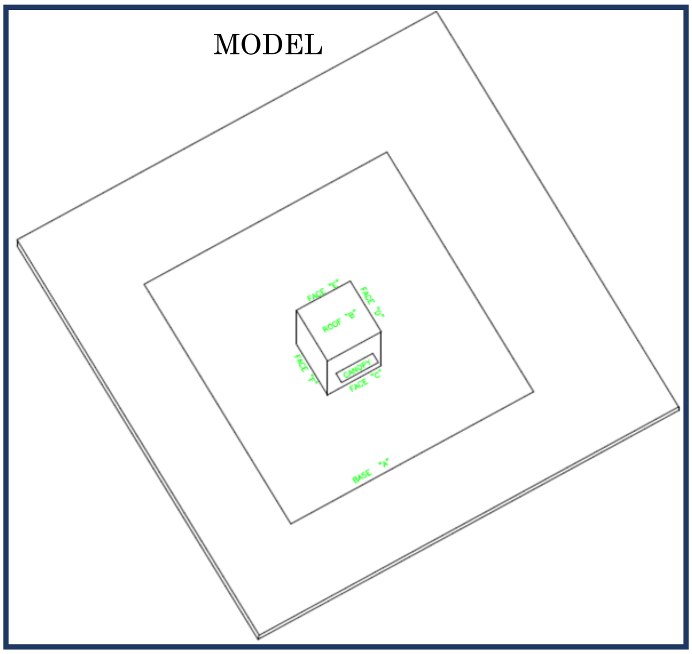
Structural Element	Number of pressure points	remarks
Flat roof	25	
Sides (4 sides)	40	10 points on each side
Canopy of length 8m (model length 20mm)	6	3 Top and 3 Bottom
Canopy of length 12m (model length 30mm)	8	4 Top and 4 Bottom
Canopy of length 16m (model length 40mm)	10	5 Top and 5 Bottom

Data Frequency of 50 Hz. Swril ratio S= (R/2h) tan θ, θ = 60 degrees, R= 206mm,h= 500mm

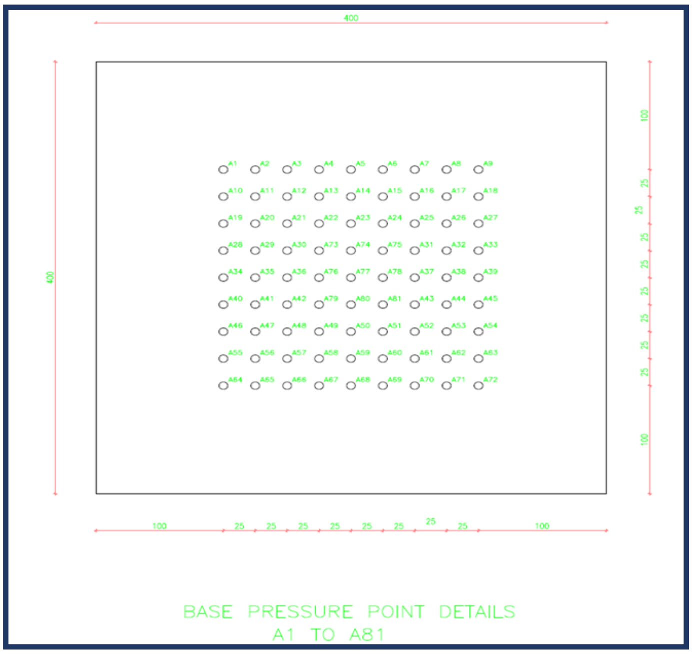
S=0.36 for the actual tornado conditions, radius of tornado = 1 to 3km, Height of tornado=0.5to2km

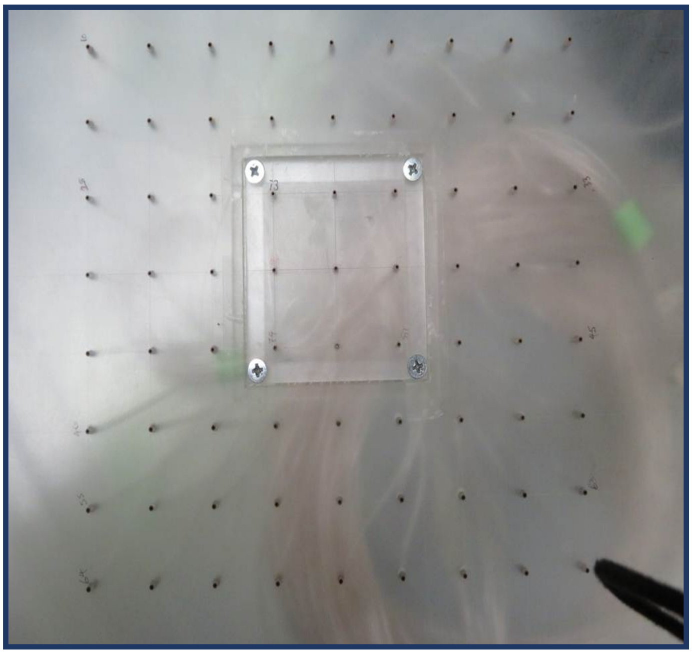


PLAN AND SECTION OF TORNADO SIMULATOR

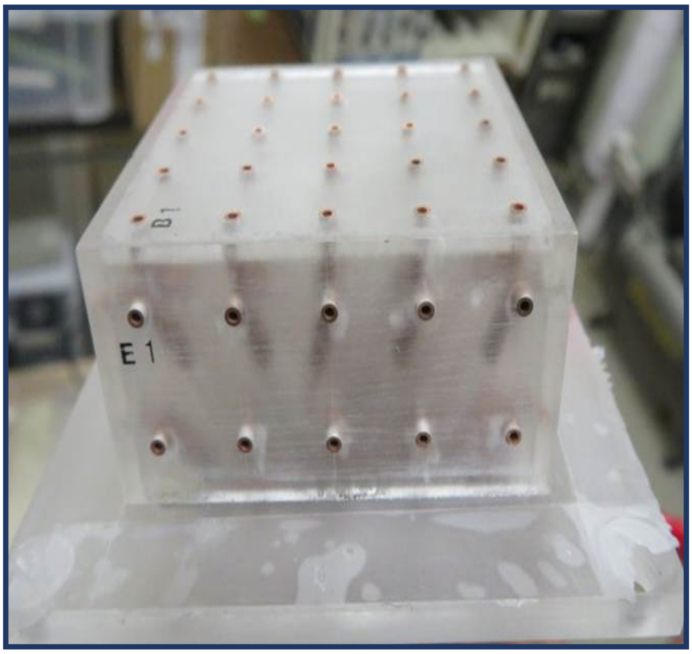


3D MODEL

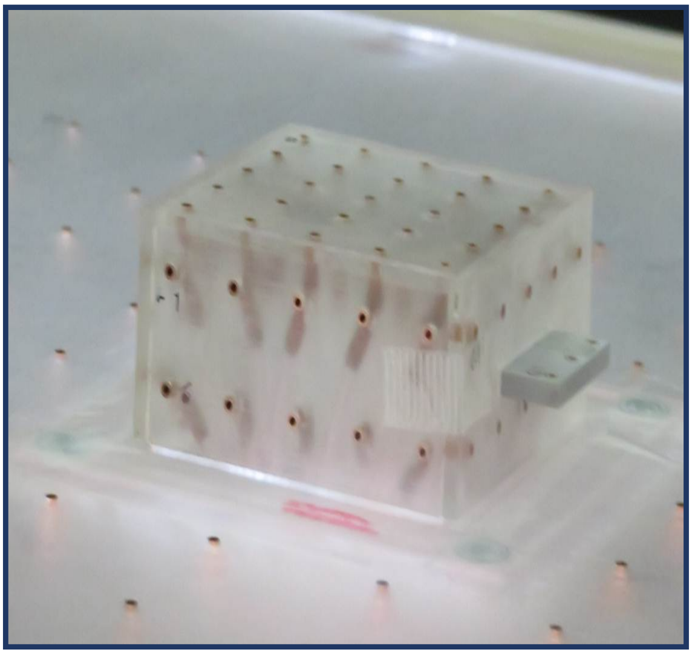




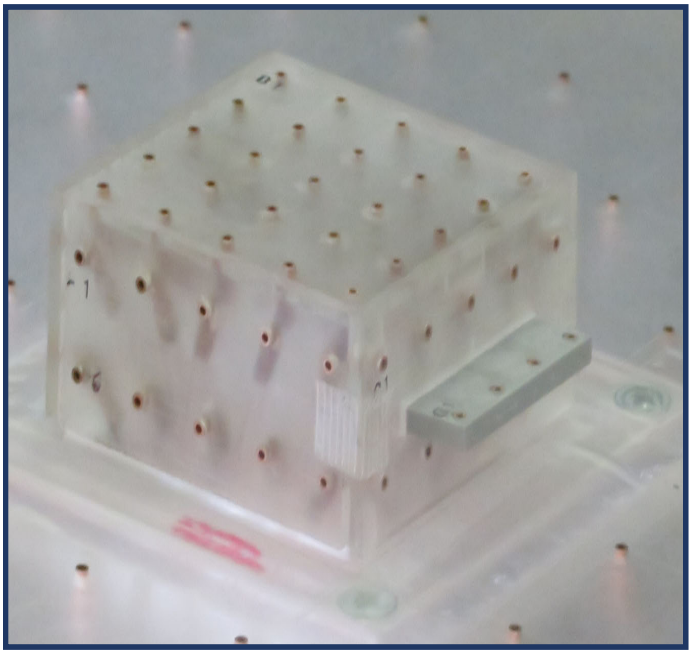
BASE PRESSURE POINTS



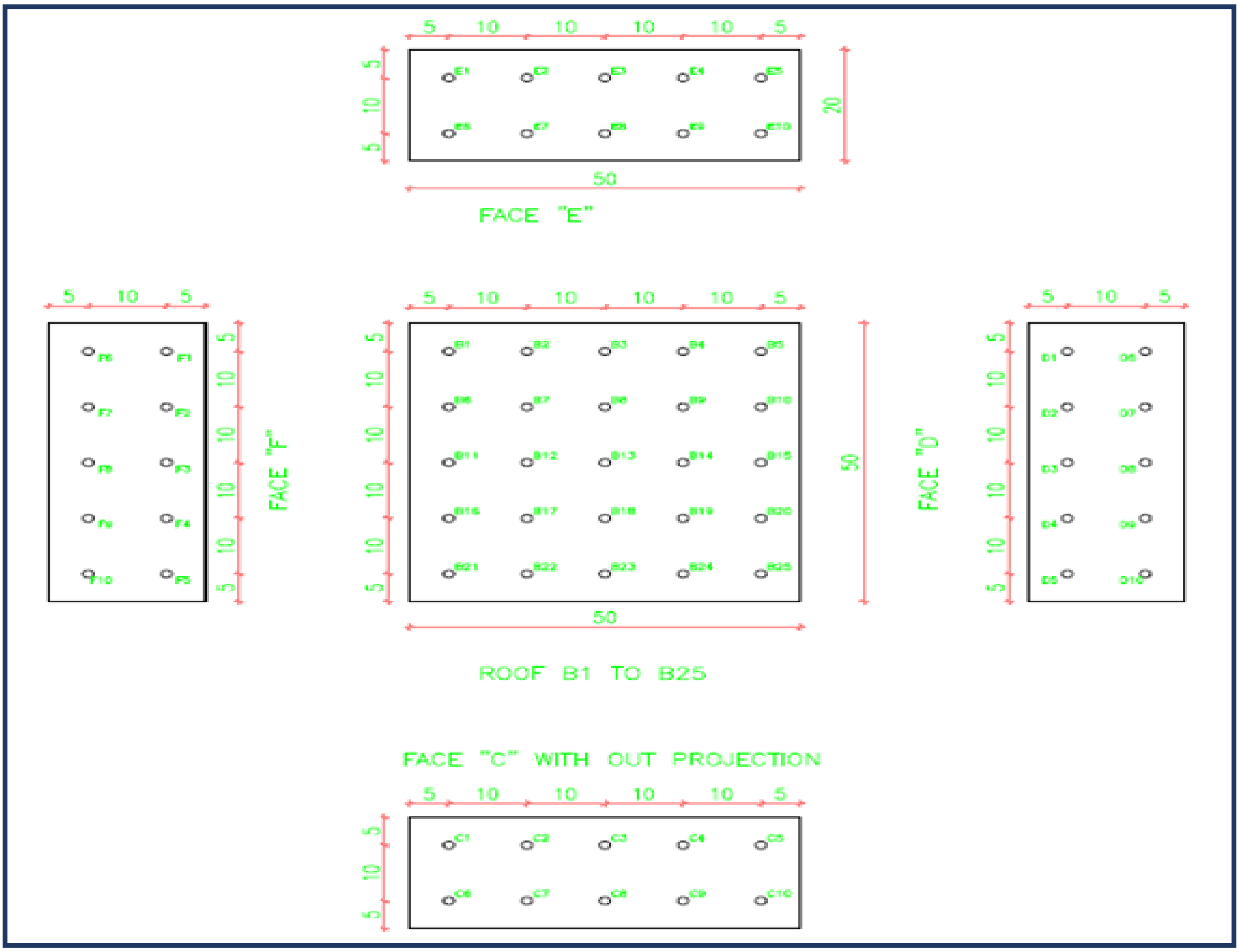
MODEL WITHOUT CANOPY



MODEL WITH CANOPY -1



MODEL WITH CANOPY -2



PESSURE POINTS DETAILS

3. Research Result

The experimental work of first proposed research plan was finished very recently. The result analysis work is in progress. It is expected that from the proposed research, more elaborated and detailed results of pressure coefficients on buildings with attached canopies will be produced. These results would be helpful in recommending more reliable pressure coefficients for building design to be incorporated in wind design code of India and Japan which could be further recommended to be used by designers for more safe design of building with attached projections which can sustain under the impact of tornadoes.

4. Published Paper etc.

[Underline the representative researcher and collaborate researchers]

[Published papers]

1. Rajesh Goyal[1] and Mohammed Moizuddin[2] "Impact of Tornado Vortex Induced Aerodynamic Loads on Structural Projections in Low Rise Buildings" International Workshop on Wind Effects on Buildings and Urban Environment, Wind Engineering Joint Usage / Research Center, Tokyo Polytechnic University, March 2019.

[Presentations at academic societies]
No

[Published books]
No

[Other]
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No

5. Research Group
1. Representative Researcher

Prof Rajesh Goyal, Dean and Professor, National Institute of Construction Management and Research (NICMAR), Delhi NCR Campus, INDIA

2. Collaborate Researchers

1. Prof. Masahiro Matsui, Director of WERC, Professor of Tokyo Polytechnic University

2. Mohammed Moizuddin, Research Scholar, Civil Engineering Department, RIMT University, Punjab, INDIA

6. Abstract (half page)

Research Theme: Wind Hazard Mitigation
Representative Researcher (Affiliation)
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The effects of wind loading on buildings due to straight line boundary layer type winds have been studied extensively in the past. The effects of vortex loading on structural projections will induce crosswind loads and torsional loads on low rise building which has severe dynamic resonant effect not only on the structural projections but also on over all structural elements of a building. These structural projections can be in the form of cantilever balconies, canopies, sunshades, overhangs, aesthetically projected elements. The purpose of each of these projections is different and designed to suit the convenience of habitats. During the tornado the damage of projections becomes flying debris due to the fatigue effect of fluctuating pressure.

It was proposed to conduct the extensive study on low rise buildings with attached canopies for different parameters under the influence of tornado induced vortexes. The building models can be tested for different parameters of attached canopies i.e. length of canopy, width of canopy, height of canopy, slope of canopy etc. So, it was planned to carry out the study on low rise building models with different parameters. In the first phase of study, influence of length of canopy was studied.
Models were tested for F3 – F4 tornado for the wind speed 60m/s to 90m/s. Tornadoes were simulated in smooth open terrain with vortex core diameters from 0.46 m to 1.06 m. A 1:400 scale model of a building of dimensions of 20m x 20m x 10 m were prepared using flexi glass. An arrangement was made to study the length of canopy effect. So front wall of building was tested with attached canopy of varying length. Models were provided with pressure tapping to measure the surface pressure on all the walls, roof and canopy upper/lower surface.

It is expected that from the present research, more elaborated and detailed results of pressure coefficients on buildings with attached canopies will be produced. These results would be helpful in recommending more reliable pressure coefficients for building design to be incorporated in wind design code of India and Japan which could be further recommended to be used by designers for more safe design of building with attached projections which can sustain under the impact of tornadoes.