Wind Engineering Joint Usage/Research Center
FY2022 Research Result Report

Research Field: Wind Hazard Mitigation
Research Year: FY2022
Research Number: 22222004
Research Theme:
Determining design wind loads on typical structures exposed to tornado like flow

Representative Researcher: Dr. Sabareesh Geetha Rajasekharan

Budget [FY2021]: 360000JPY

1. Research Aim

To estimate design wind loads on typical structures exposed to tornado like flow
Based on the theme, major objectives are formulated as

(1) Estimation of peak wind loads on typical structures exposed to tornado-like flow
(2) Comparison of fluctuating components of wind loads between different simulators worldwide.
(3) Estimation of design wind loads on a gable roof structure exposed to tornado-wind load

2. Research Method

Fabricating pressure models and exposing to tornado-like flow, estimating peak pressures from different simulators.

Figure 1 shows the location of building model with respect to tornado vortex. Figure 2 shows the arrangement of pressure taps of the scaled-down TTU benchmark building model. The model size is 60×40×17.5mm, with a total of 121 pressure taps. The geometric scaling ratio is 1:300 and the velocity scaling ratio is 1:5.

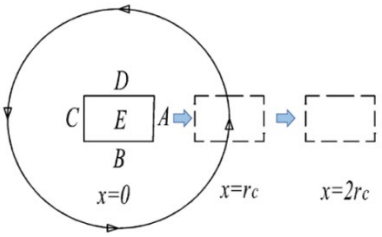


Figure 1 Location of building model with respect to tornado vortex

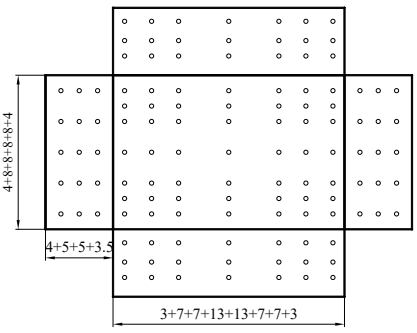


Figure 2 Pressure Tap layout- TTU Model

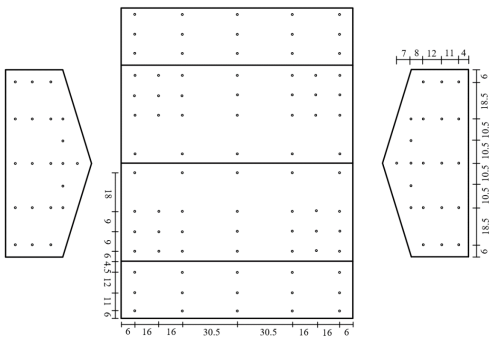


Figure 3 Pressure tap layout-Gable roof model

3. Model preparation using 3-D printer

ABS/PLA material was used initially to prepare the building models as shown in Figure 4. It has been observed that the prepared model was having considerable surface roughness and the holes for pressure tap locations couldn't be obtained precisely. Here each side of the building model was 3-D printed separately.

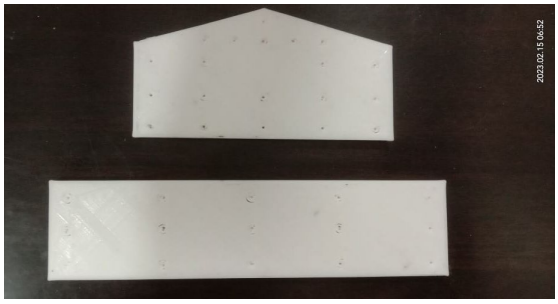


Figure 4 Building model walls- ABS material

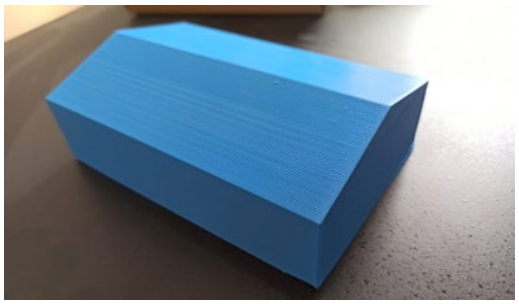


Figure 5 Gable roof building made using ABS

A second attempt was made to print the building model using 3-D printer with the entire structure all at once as shown in Figure 5. This attempt helped in preparing the model to the exact dimensions but at the time when attempt was made to introduce holes for pressure taps at the corners, the model broke.
Finally attempts were made to prepare the building models as per the design shown in Figure 2, using acrylic sheet. This helped in obtaining the walls and location of pressure taps with precision as shown in Figure 6.

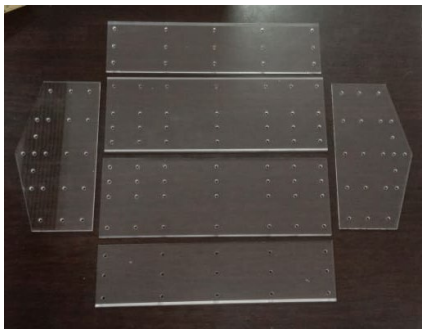
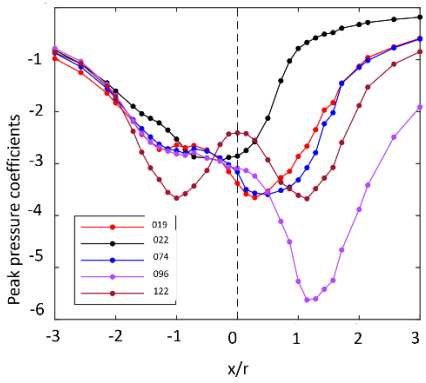
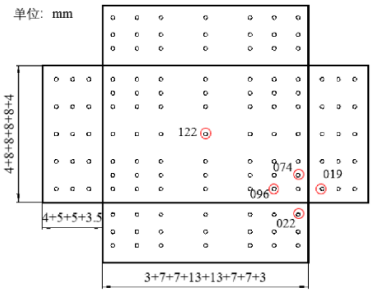


Figure 6 Exploded view of model made using Acrylic material

4. Research Results

The results obtained in this FY include, estimation of RMS pressure coefficient on the building walls of TTU building model. The fluctuating components of pressure coefficients are important from the design point of view. Further, the peak pressure coefficients and design loads were estimated on the building model. Also, comparison is made between different locations as shown below. Although mean pressures were compared and encouraging results were obtained in earlier FYs, it further demands the extension of the present work to estimate the peak pressures which are important from the design point of view, which are presented in this FYs results.
Figure.7 shows the variation of peak pressure coefficients at strategic locations of building model.
The results obtained by comparing the results between different simulators were communicated to 16th International Conference on Wind Engineering at Florence, Italy and the paper is accepted for oral presentation. The paper is titled "Benchmark studies on a building model exposed to tornado-like flow in three different simulators " authored by Sabareesh G R, Masahiro Matsui, Partha Sarkar, Shuyang Cao. This paper discusses on the characteristics benchmarked between the different simulators, the velocity profile obtained and compared between the different simulators and also the design wind loads compared between the different simulators.





(a) Peak pressure coefficients (b) Location of pressure taps

Figure 7 Peak Pressure Coefficients at strategic locations on building model

5. Published Paper etc.

1. Sabareesh G R, Masahiro Matsui, Partha Sarkar, Shuyang Cao, Benchmark studies on a building model exposed to tornado-like flow in three different simulators, Paper accepted for oral presentation at 16th ICWE, Florence

6. Research Group

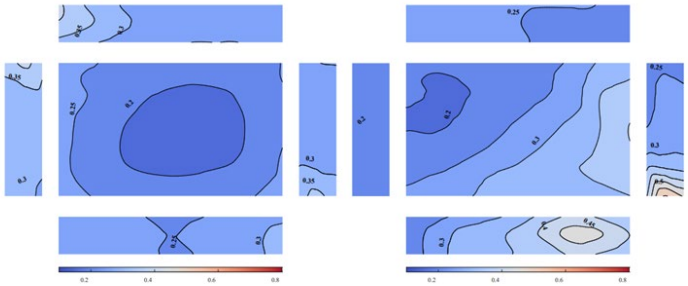
1. Representative Researcher
   Dr Sabareesh Geetha Rajasekharan
2. Collaborate Researchers
   Prof Masahiro Matsui, TPU, Japan
   Prof Shuyang Cao, Tongji University, China
   Prof Partha Sarkar, Iowa State University, USA

Abstract

Research Theme: Determining design wind loads on typical structures exposed to tornado like flow

Representative Researcher (Affiliation): BITS-Pilani Hyderabad campus

The RMS fluctuating component of wind loads were estimated on building models exposed to tornado like flow simulator. The results are presented in form of contours of Cp rms on building model. The location of building model with resect to the tornado vortex was varied in the Tongji Simulator.



（a） $x=0$ （b） $x=0.5r_c$

- RMS pressure coefficients on each surface as well as total force coefficients evaluated
- Tangential wind velocity and pressure drop of tornado vortices was responsible for wind loads.
- Wind loads changes with respect to distance from tornado to building model
- Worst case of pressure coefficients is recorded near roof corner
- Also attempts were made in this FY to fabricate building models using 3-D printing technology, which will be further used in the next FY