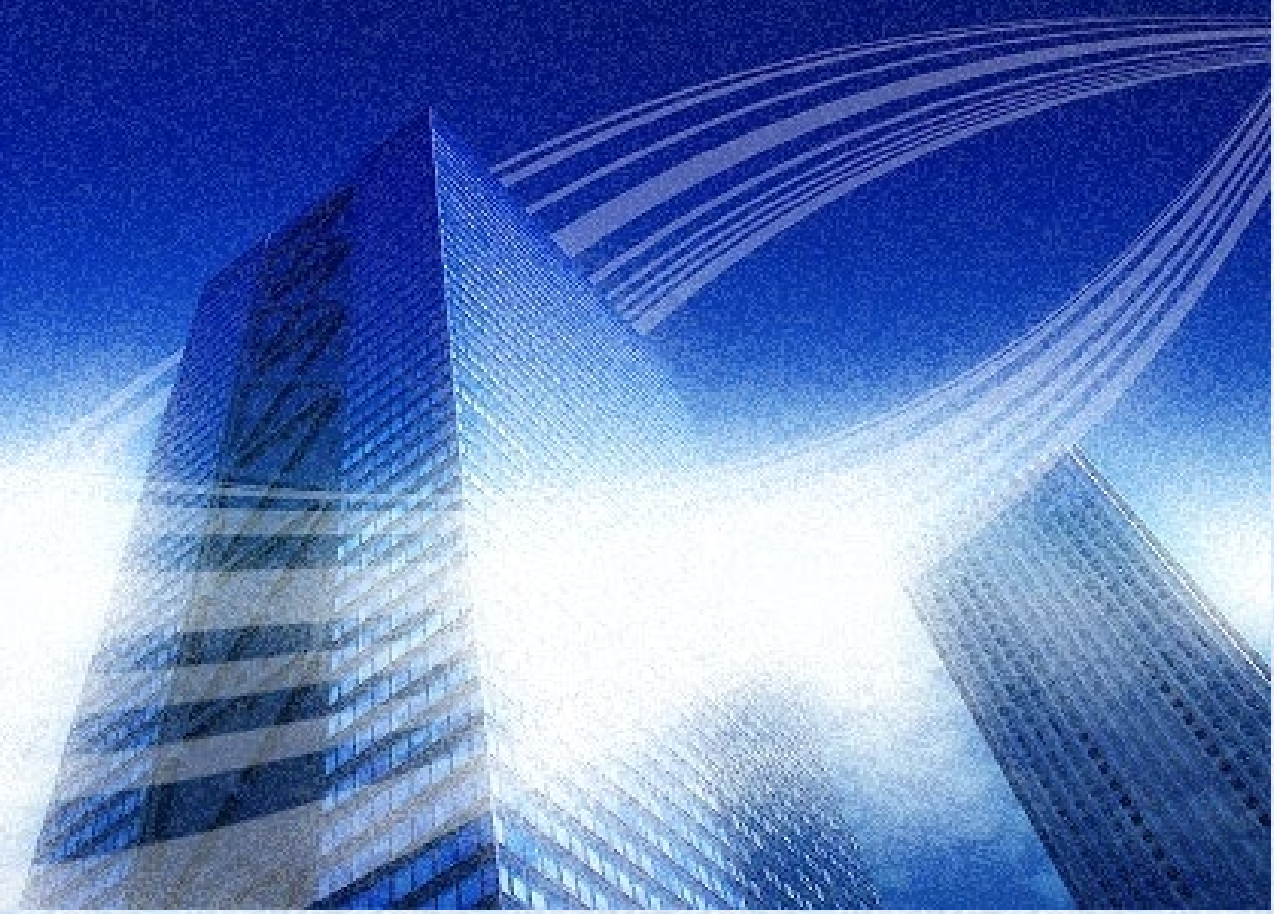


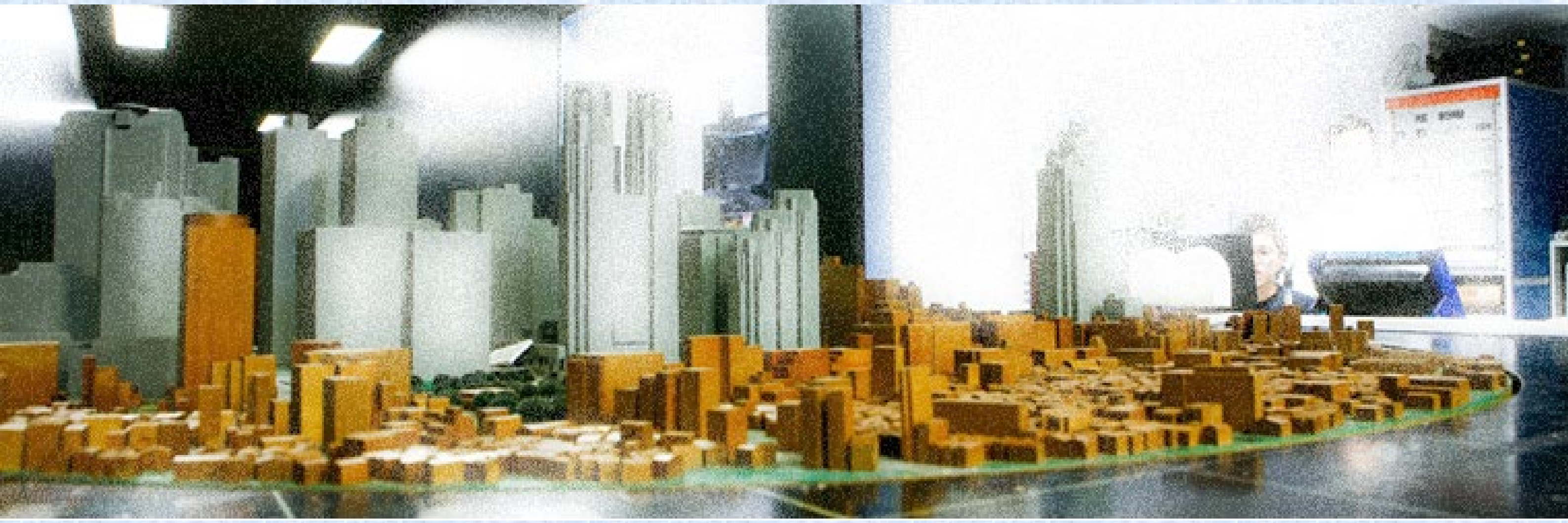
Wind Effects on Buildings and Urban Environment

Tokyo polytechnic University

Wind Engineering Research Center

MEXT Joint Usage/Research Center

—Research Facilities—



TOKYO POLYTECHNIC UNIVERSITY

Turbulent Boundary Layer Wind Tunnels for Structural Studies

To evaluate wind loads and habitability of super-tall buildings and/or large-span structures, various wind tunnel tests were conducted in two turbulent boundary layer wind tunnels of different sizes

Large-size wind tunnel

- Test section: W 2.2m, H 1.8m, L 19.0m
- Wind speed: 0.5 ～ 15m/s

Medium-size wind tunnel

- Test section: W 0.9m, H 0.9m, L 14m
- Wind speed: 0.5 ～ 14m/s

Measuring equipment

- Multi-channel pressure measurement system (384ch)
- Force balance
- Gimbal
- Multi-channel thermistor anemometer (96ch)
- Hot-wire anemometer
- Laser sheet for visualization

Wind tunnel test models

Large-size turbulent boundary layer wind tunnel

Situation of wind tunnel test

Medium-size turbulent boundary layer wind tunnel

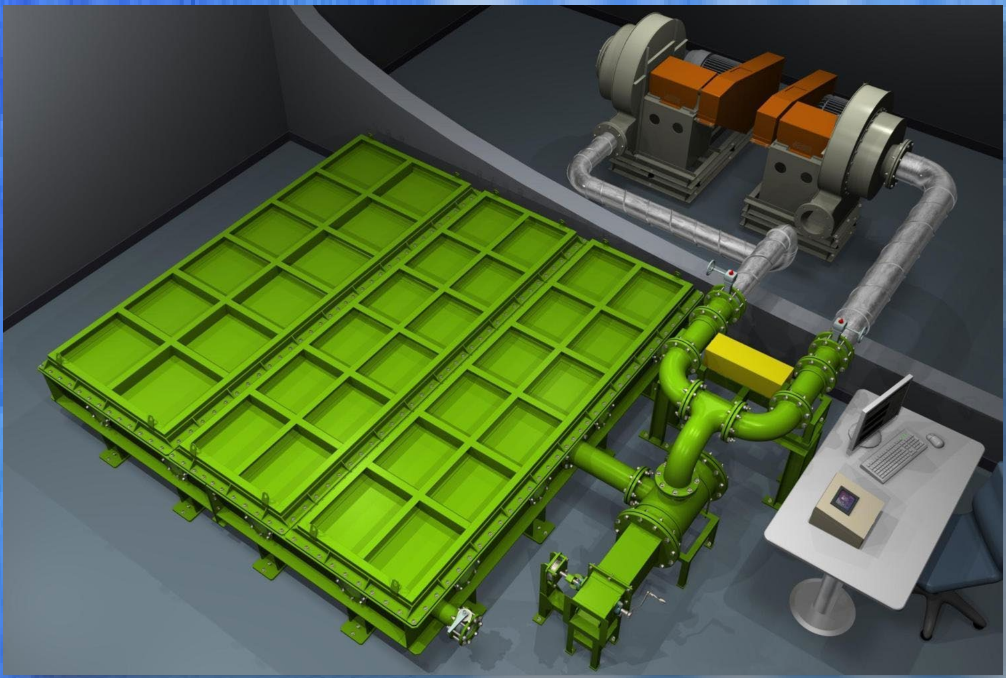
Exterior Material Wind Resistance Test Equipment

Many failures have occurred of wall, roof, and ceiling claddings resulting from gusty winds due to tornadoes and strong winds due to typhoons. Many wind-tunnel pressure measurements have been conducted and these failures and reasons for them have been verified. External pressures acting on claddings can be estimated. However, it has been difficult to estimate the strengths of claddings and their support systems. The test method described here can simulate the behaviors of claddings and their support systems both statically and dynamically.

Specification

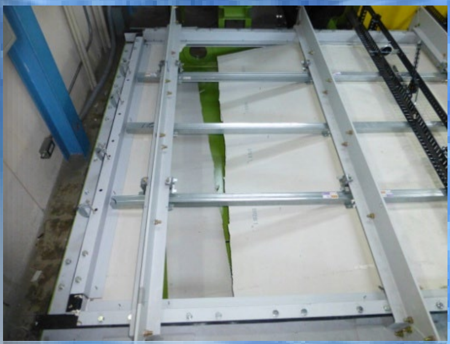
- Size of chamfer: 3.0m× 3.0mm × 0.3m
- Pressure range: -10kPa ～ 10kPa
- Pressurizing method: static, sinusoidal, random

Exterior wall



Schematics of exterior material wind resistance test equipment

Destruction of ceiling



Ceiling wind resistance test

Setting of specimen

Test of artificial waterproof system with mechanical fixing

Tornado-like Flow Simulator

To reduce tornado damage, characteristics of pressures on structures need to be examined.
The tornado-like flow simulator in TPU can simulate moving tornados as well as static tornados.
In the experiments, various experimental conditions can be adjusted to simulate tornado-like flows with various characteristics.

Tornado Damage, Monbetsu, Hokkaido, 2004

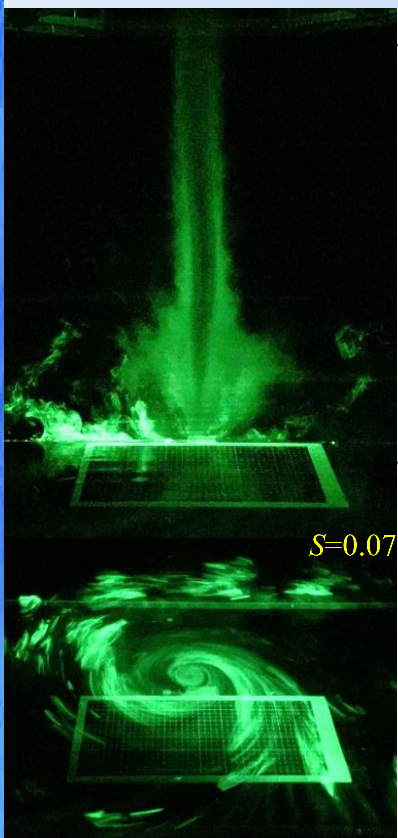
Tornado Damage, Koshigaya, Saitama, 2013

Upward and moving flow generating equipment

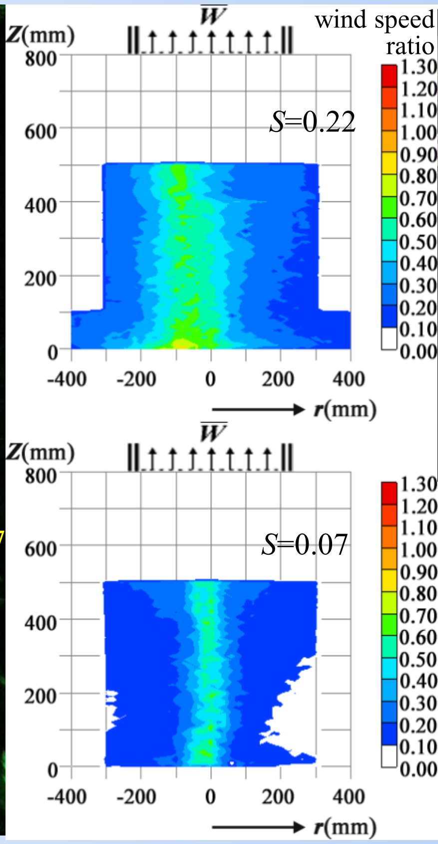
- maximum moving velocity : 4m/s
- Width : 1700mm
- Updraft hole : 410mm
- Upward flow velocity : 6.5m/s
- Adjustable floor

Measurement system

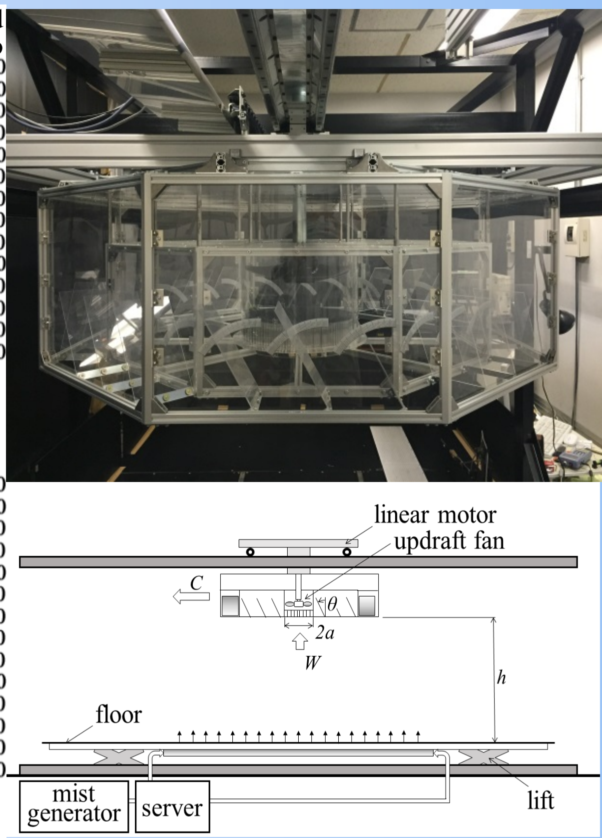
- Visualization system (H_2O mist)
- Pressure measurement system (256ch.)
- Wind speed measurement system (hot-wire prove, thermistor probe, PIV)



Visualization of Tornado-like Flow



Wind Speed Measurement Results



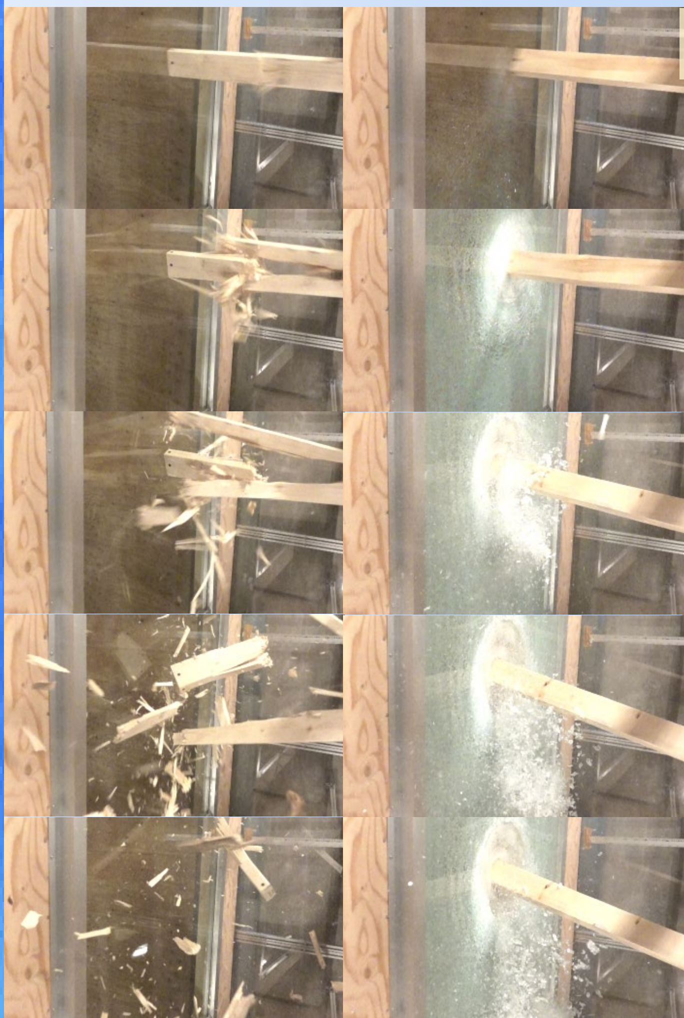
Tornado-like Flow Generator

Debris Impact Facility (Air Cannon)

A facility that simulates high-speed (up to 100m/s) flying objects resulting from typhoons and tornadoes, and conducts impact tests on exterior wall materials and windowpanes.

Tornado-borne flying debris penetrating exterior walls (Atsuga, Hokkaido, 2004)

Collision marks caused by tornado-borne flying debris impacting walls (Nobeoka, Miyazaki, 2006)



Debris Impact Facility (Air Cannon)

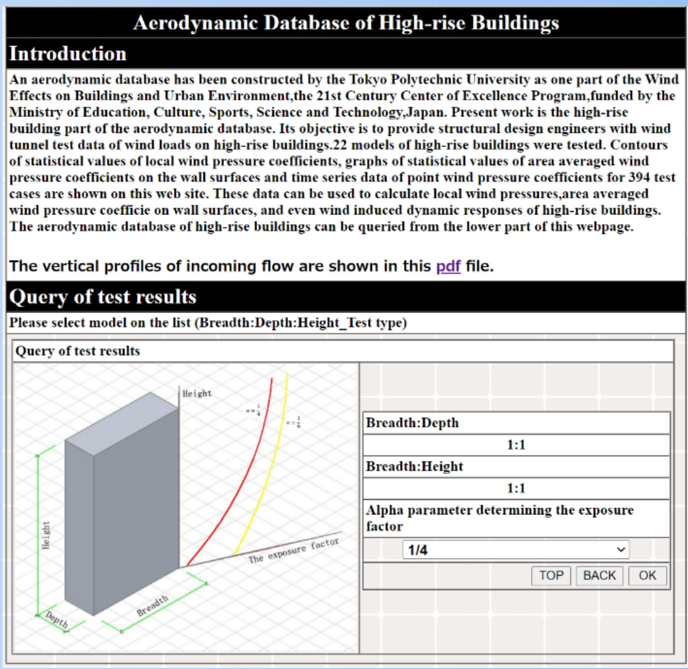
Examples of impact tests on window panes with two-by-four cut pieces of wood
Laminated glass reinforced by resin showed impact resistance to flying objects. (pictures on left)

TPU Wind Engineering Database

(https://werc.t-kougei.ac.jp/TPUdatabase.html)

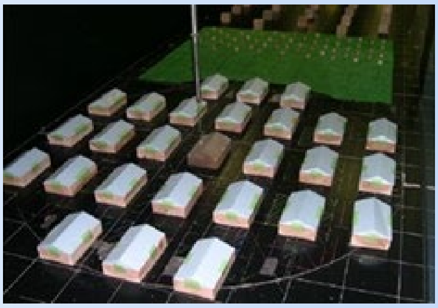
TPU Aerodynamic Database

This database is an international database containing 6 experimental results, as shown below. Researchers, Structural Engineers, and Students can use it freely. When you search data, you can select a different experimental parameter (Building Plan, Building Height, Ground Surface Roughness Classification, and so on). You can download not only "Contours of Wind Pressure Coefficient" as an experimental result but also "Time History Data of Wind Pressure Coefficient" (Matlab file). This database is being referred for creating domestic and international standards and design materials and is accessed from all over the world.

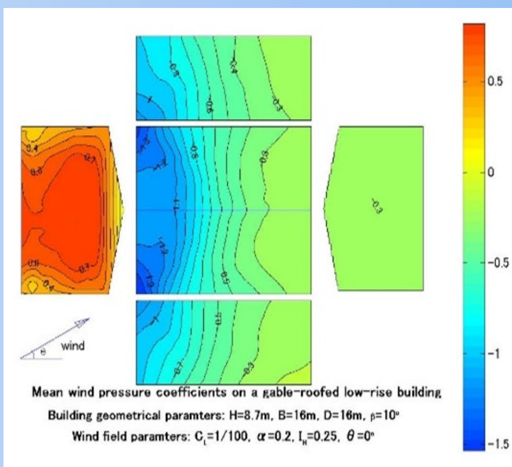


TPU Aerodynamic Database

- Wind Pressure Database for High-Rise Building
- Wind Pressure Database of Two Adjacent Tall Buildings
- Database of Isolated Low-Rise Building without Eaves
- Database of Isolated Low-Rise Building with Eaves
- Database of Non-Isolated Low-Rise Building
- Database of Universal Equivalent Static Wind Load Distribution



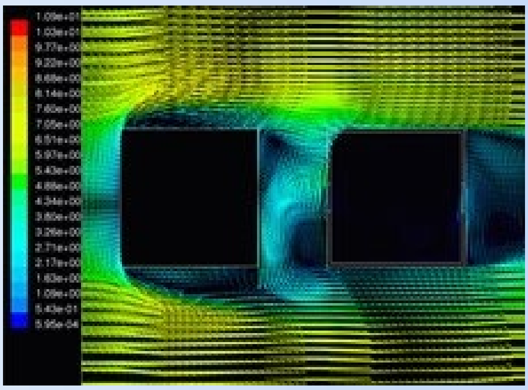
Database of Non-Isolated Low-Rise Building



Aerodynamic Database of Low-Rise Building

Database of Cross Ventilation

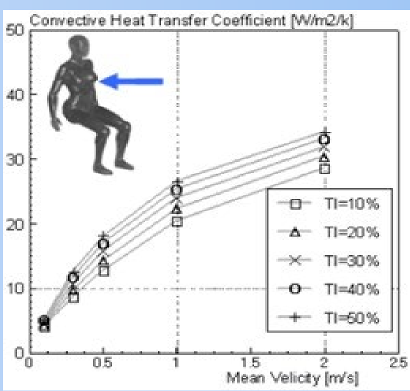
This data base was created based on the results obtained from CFD analyses related to residential wind speed vectors and indoor airflow characteristics.



Database of Cross Ventilation

Database of Indoor/Outdoor Air Pollution

This database is related to a numerical human body model and airflow/temperature/density around a building.



Database of Indoor environment

Thermally Stratified Wind Tunnel

This is a special wind tunnel that can control floor temperature and airflow temperature. It consists of a fan, temperature stratification equipment, floor panel heating/cooling equipment, an air flow cooling system, and a heat source device.

It can simulate pollutant/thermal dispersion under various conditions of atmospheric stability, and urban heat island phenomena.

Pollutant dispersion in a city

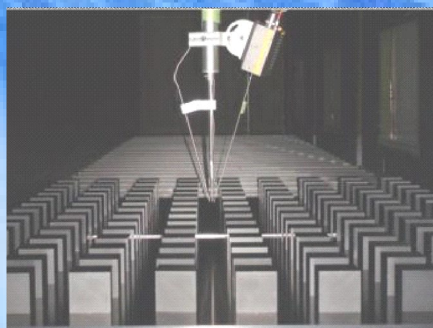
Specification

- Test section: W 1.2m, H 1.0m, L 9.4m
- Wind speed: 0.2～2m/s
- Airflow temperature: 12℃～60℃
- Floor surface temperature: 9℃～80℃

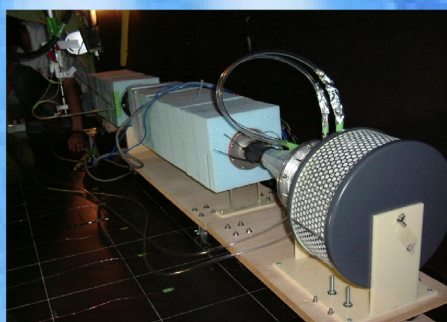
Measuring equipment

- Fast Response Flame Ionization Detector (FID)
- Calibrator for hot/cold-wires
- Hot-wire anemometer including split film probe
- PIV (Particle Image Velocimetry) measurement system
- System for simultaneously measuring fluctuating velocity, temperature and concentration in non-isothermal flows

Stagnation of heat and pollutant due to poor ventilation in a dense city



Simultaneous measurement of fluctuating velocity, temperature and concentration



Calibrator for hot/cold wires

Turbulent Boundary Layer Wind Tunnel for Environmental Studies

This is an open-circuit wind tunnel designed for assessment of pedestrian wind environments, pollutant dispersion under neutral conditions, and ventilation studies.

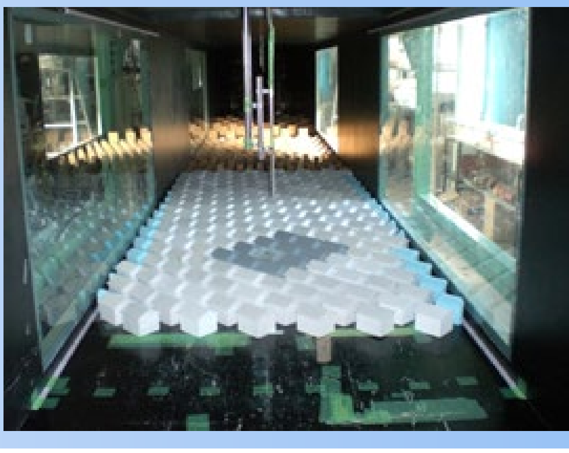
A remote control instrument carriage allows positioning of a probe within 0.1mm of surfaces in the measuring section.

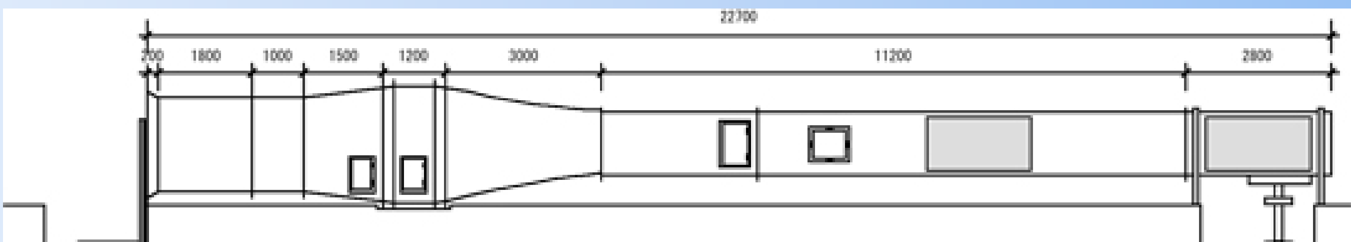
Specification

- Test section: W 1.2m, H 1.0m, L 14.0m
- Wind speed 0.5〜18m/s

Measuring equipment

- Fast Response Flame Ionization Detector (FID)
- Hot-wire anemometer including split film probe
- High-precision manometer
- PIV (Particle Image Velocimetry) measurement system

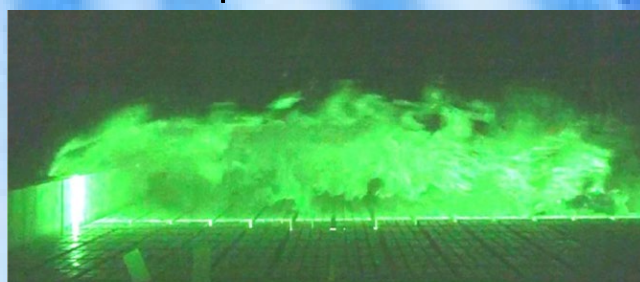




Section

Wind tunnel experiment of pollutant dispersion

Wind tunnel experiment of natural ventilation

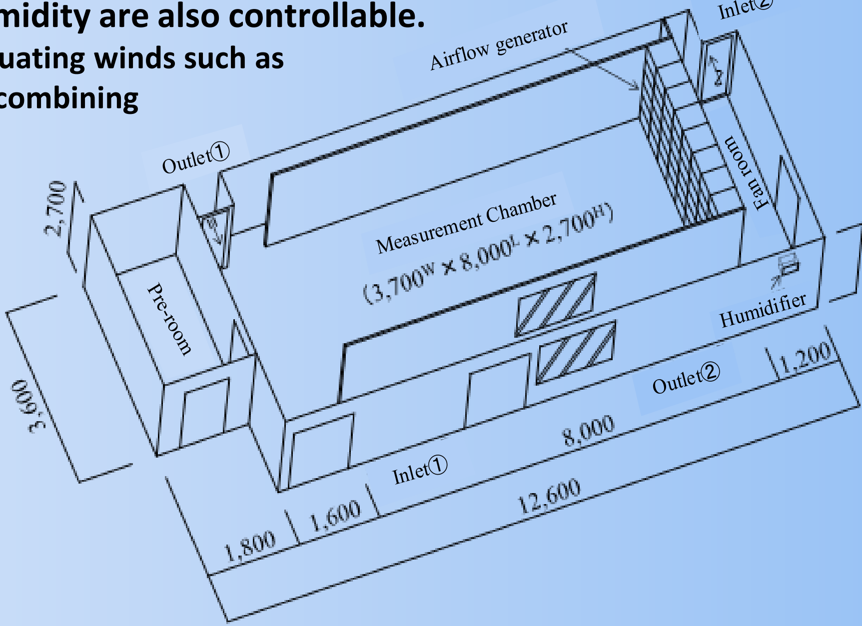


Flow visualization behind high-rise buildings

Active-Control Multi-fan Climatic Chamber

The climatic chamber is a special device that can produce any wind fluctuations and velocity distributions using 48 plug fans controlled individually by inverters.
The indoor temperature and humidity are also controllable.

By reproducing natural winds, fluctuating winds such as sine waves and square waves, and combining temperature and humidity control, you can examine the comfort, arousal, and intellectual productivity of various environments.



Specifications

- Dimension: W 5m, H 3m, L 11m
- Wind velocity: 0.1～2.7 m/s
- Temperature: 20~35℃ ± 0.5℃
- Humidity: 40~70% ± 2%

Typical use:

- Subjective experiment related to thermal sensation and comfort with natural ventilation.
- Subjective experiment related to thermal sensation and comfort with radiative and convective air-conditioning system combined with desiccant system.
- Subjective experiment on the effects of wind speed variation and temperature change on intellectual productivity.
- Visualization experiment of airflow around human body using thermal manikin.
- Measurement and visualization experiment of jet airflow from full-scale diffuser.
- Verification experiment of human body thermal physiological model using a sweating thermal manikin.

Measurement chamber

Airflow generator

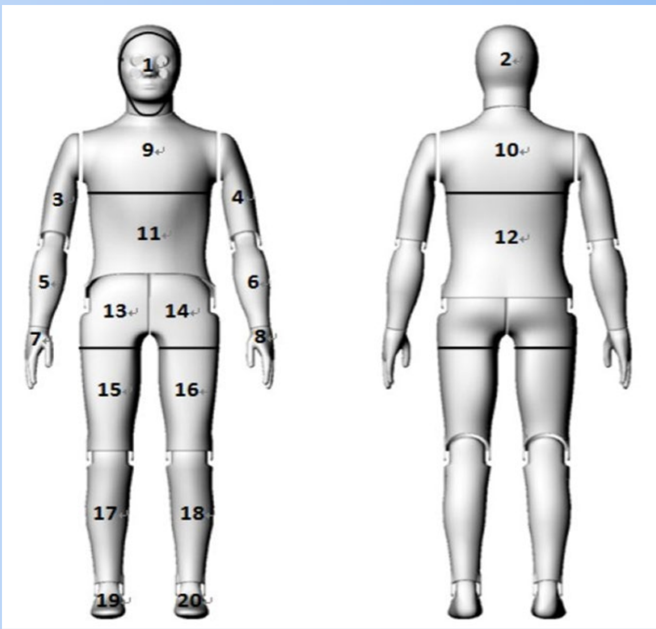
Status of subjects experiment

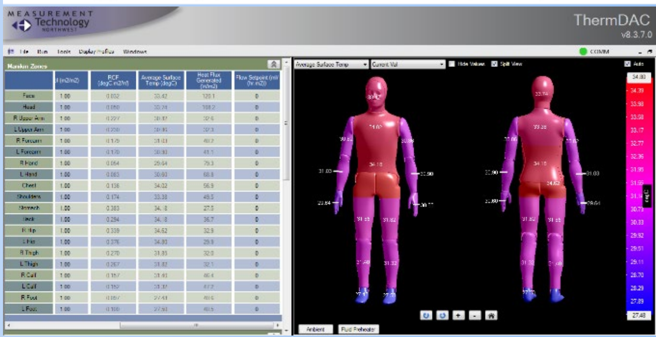
Sweating Thermal Manikin

Simulates the body shape of an Asian male with a height of 168.5 cm, and can control the surface temperature, heat, and sweat for each of a total of 20 parts including the face, head, chest, abdomen, shoulder, back, upper arm, forearm, buttocks, thighs, lower limbs, and feet.

For the control method, surface temperature control, heat flux control and comfort mode control are possible for each part.

Sweating is reproduced by dispersing and evaporating distilled water from 139 sweat holes with a special skin. The amount of perspiration can also be controlled for each part.





Sweating thermal manikin specification

- Newton20-Zone manufactured by MTNW, USA
- Height 168.5cm, weight 30kg
- Maximum heat generation 800W /m²
- Maximum sweating 1000ml / (hr・m²)
- Humidity range 30-90% (± 2%)

Main uses

- Verification experiment of human body thermal physiological model
- Measurement experiment of thermal resistance and moisture permeability resistance of various kinds of clothing
- Evaluation of thermal environment in various air-conditioned rooms and personal air-conditioning systems.
- Experiment to measure heat transfer coefficient around the human body by various air-conditioning methods, human body shapes, and kinds of clothing.
- Experiment of airflow and visualization around the human body by various air-conditioning methods, human body shapes, and kinds of clothing.

Clothing state

Situation experiment simulating a nude body

The Joint Usage/Research Center (JURC) Operating Organization

Our purpose is to contribute to reinforcement and development of human resources and to development in the wind engineering field by sharing world leading knowledge in this field and providing unique research facilities. We have set up the Joint Usage/Research Center Steering Committee in the Wind Engineering Research Center to achieve this purpose.

JURC Steering Committee External Member

Takeshi Ohkuma	Professor Emeritus at Kanagawa University, Guest Researcher at Kanagawa University
Shinsuke Kato	Program-Specific Professor/Professor Emeritus at Tokyo University Project Professor at Kougakuin University
Takashi Kurabuchi	Vice-president/Professor at Tokyo University of Science
Nobuyuki Kobayashi	Professor Emeritus at TPU
Yoshihide Tominaga	Professor at Niigata Institute of Technology (Director at wind/Fluid Engineering research center)
Aakashi Mochida	Professor at Tohoku University, Graduate school of Engineering and Faculty of Engineering
Tomomi Yagi	Professor, Kyoto University, Graduate School of Engineering, Department of Social Infrastructure Engineering
Hitoshi Yamada	Professor Emeritus at Yokohama National University, Guest Professor at Kanto Gakuin University
Akira Wada	Professor Emeritus at Tokyo Institute of Technology

TPU Internal Member

Akihito Yoshida	Professor and Director at Wind Engineering Research Center, Wind Hazard Mitigation field
Yong Chul Kim	Professor, Wind Hazard Mitigation field
Xuan Yingli	Assistant Professor, Outdoor Environment field
Masahiro Matsui	Professor, Wind Hazard Mitigation field
Kunio Mizutani	Professor, Cross Ventilation/Indoor Environment field
Yoshihide Yamamoto	Associate Professor, Cross Ventilation/Indoor Environment field
Ryuichiro Yoshie	Professor, Outdoor Environment field
Yukio Tamura	Professor Emeritus at TPU, Program Coordinator, Wind Hazard Mitigation

Major Joint Research Institutes

(Japanese University and National Institute of Technology)
Ashikaga University, Kanagawa University, Kanto Gakuin University, Kyoto University, Kochi University, Tokai University, Tokyo University, Tokyo Institute of Technology, Tokyo University of Science, Tohoku University, Tokushima University, Tokoha University, Nagoya University, Niigata University, Niigata Institute of Technology, National Institute of Technology Toyota College, Japan Women's University, National Defense Academy of Japan, Musashino University, Meiji University, Waseda University

(Foreign Colleges)
University of Notre Dame (USA), University of Genoa (Italy), Chongqing University (China), Beijing Jiao Tong University (China), Tongji University (China), University of Western Ontario (Canada), Indian Institutes of Technology (India), Pusan National University (Korea), Tamkang University (Taiwan)

(Private Company)
Obayashi Corporation, Wind Engineering Institute, Shimizu Corporation, Taisei Corporation, Takenaka Corporation, Tokyu Construction, Maeda Corporation

(Public Research Institutes)
National Institute for Land and Infrastructure Management (NILIM), Japan Aerospace Exploration Agency (JAXA)

Joint Usage/Research Center Internal Members

(As of April 2021)

Professor Akihito Yoshida, Director, Wind Engineering Research Center, Wind Hazard Mitigation field

Professor Ryuichiro Yoshie, Outdoor Environment field

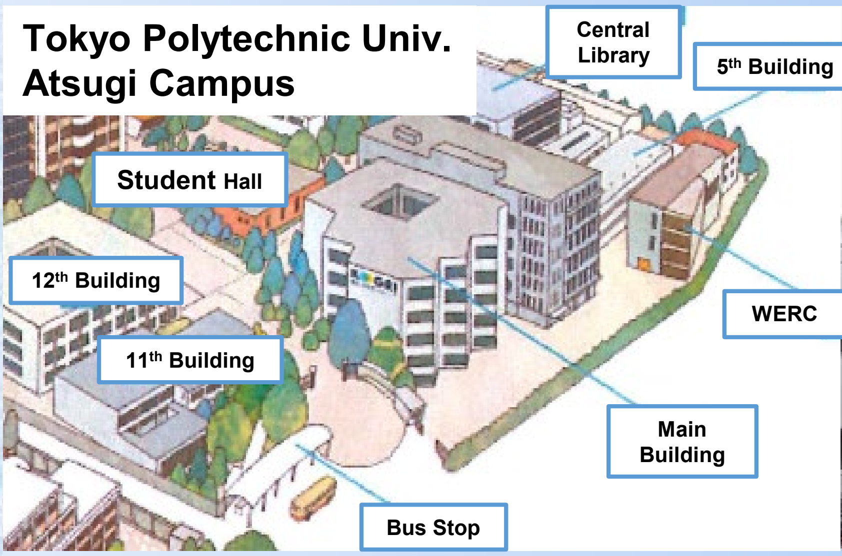
Professor Masahiro Matsui, Wind Hazard Mitigation field

Professor Yong Chul Kim, Wind Hazard Mitigation field

Associate Professor Yoshihide Yamamoto, Cross Ventilation/Indoor Environment field

Assistant Professor Xuan Yingli, Outdoor Environment field

JURC Program Coordinator Yukio Tamura, Professor Emeritus of TPU



Tokyo Polytechnic University Wind Engineering Research Center
Joint Usage/Research Center Office
5-45-1 Iiyamaminami, Atsugi, Kanagawa, Japan 243-0297
Phone: +81 (0) 46 242 9658 E-mail：collaborate@arch.t-kougei.ac.jp