Research with advanced building simulation conducted at Environmental Research & Design Laboratory (ERDL) of School of Architecture

Manfred Zapka, PhD, PE
Adjunct Professor
Sustainable Advisor
Environmental Research and Design Laboratory
UHM’s School of Architecture
What is research in Architecture?

• Quantitative versus qualitative
• Exploratory research; e.g. qualitative studies or defining research
• Explanatory research, e.g. quantitative studies and hypothesis testing
• Descriptive research, e.g. quantitative studies or a combination of qualitative and quantitative studies

How do you see the role of research in architecture?
• The goal of Research is expanding the body of knowledge through the application of scientific principles, including systematic observation, measurement, and experiment, reasoning based on empirical and measurable evidence and the formulation, testing, and modification of.

• The central premise of scientific research endeavors to let reality speak for itself.

But how real is reality?
Our research in building performance is about systems and simulation of the system’s response to varying external stimulus.
Our reality consists of definition of systems and the calculated response of these systems to external stimuli.

How “real” is our “Virtual reality”?

How “relevant” is what our virtual reality is teaching us?
Defining the system, including boundaries, properties and interconnections

Describing system in mathematical and physical terms

Using analytical or probabilistic algorithms to obtain qualitative results

Verification of system performance in “objective reality”

Virtual reality

“Objective” reality or the “real world”
What is the role of advanced building performance testing in architecture?

What do you think?
We are currently are carrying out the following research in building performance simulations:
1. Building energy simulation (through energy modeling)
2. Ventilation and thermal building performance
3. Occupant comfort
Building energy simulation (energy modeling):
Ventilation and thermal building performance through Computational Fluid Dynamics (CFD)

Source: T. van Hooff & B. Blocken, 2009, On the effect of wind direction and urban surroundings on natural ventilation of a large semi-enclosed stadium
Occupant comfort studies
(prediction through CFD)
Computational Fluid Dynamics (CFD) Research at the University of Hawai‘i at Manoa

USING CFD TO INVESTIGATE NATURAL VENTILATION OF BUILDINGS IN TROPICAL CLIMATE

Manfred J. Zapka, Ph.D., P.E.
Tuan Tran, D.Arch
Sanphawat Jatupatwarangkul, D.Arch
Stephen Meder, D.Arch
Eileen Peppard, MS
Jim Maskrey, HNEI-Project Sponsor
Aarthi Padmanabhan, D.Arch
Phyllis Horner, PhD
Christian Damo, Graduate Assistant
Charles Siu, Graduate Assistant

Team photo (left to right): Sanphawat, Charles, Aarthi, Tuan, Eileen, Christian, Manfred, Phyllis
Some Examples of Optimizing Building Envelope Using Building Simulation Tools

WENDY MEGURO
Assistant Professor
School of Architecture, University of Hawaii at Manoa
Landscape shades building
IIT Mies Van de Rohe

Current Conditions, looking SE

Proposed Conditions, looking SE

Current Conditions

Proposed Conditions

Credit: atelier ten
Two runs (one for each façade)
Two screenshots compiled in Photoshop

Credit: atelier ten
GSA Federal Office Building
Miramar, Florida, USA
Office
375,000 s.f.
Completed 2014
Construction Cost $____
Pursuing LEED NC v3 Gold
General Services Administration (client)
Krueck + Sexton Architects
Atelier Ten (environmental)
WSP Flack + Kurtz (MEP)
Curtis + Rogers (landscape)
Thornton Tomasetti (structural)
Shephird Associates (envelope)

Design Excellence Award Winner
Comparison of incident solar radiation on long vertical facades in two orientations
RIGHT Tools for BEST Designs

TUAN TRAN, D.Arch
Postdoctoral Fellow
Environmental Research and Design Laboratory
UHM’s School of Architecture
<table>
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**Psychrometric Chart**

California Energy Code

**Legend**

- **Comfort**
  - 100% = Comfortable
  - 0% = Not Comfortable

**Design Strategies: January through December**

- 5.5%: 1 Comfort (478 hrs)
- 30.8%: 2 Sun Shading of Windows (2702 hrs)
- 8.3%: 3 High Thermal Mass (731 hrs)
- 8.4%: 4 High Thermal Mass Night Flushed (733 hrs)
- 3.3%: 5 Direct Evaporative Cooling (291 hrs)
- 5.7%: 6 Two-Stage Evaporative Cooling (496 hrs)
- 54.1%: 7 Natural Ventilation Cooling (4740 hrs)
- 51.8%: 8 Fan Forced Ventilation Cooling (4539 hrs)
- 13.4%: 9 Internal Heat Gain (1070 hrs)
- 0.7%: 10 Passive Solar Direct Gain Low Mass (57 hrs)
- 5.8%: 11 Passive Solar Direct Gain High Mass (504 hrs)
- 0.0%: 12 Wind Protection of Outdoor Spaces (0 hrs)
- 0.0%: 13 Humidification Only (0 hrs)
- 14.7%: 14 Dehumidification Only (1200 hrs)
- 24.3%: 15 Cooling, add Dehumidification if needed (2130 hrs)
- 0.0%: 16 Heating, add Humidification if needed (0 hrs)

**Location:** Honolulu Intl Arpt, HI, USA
Latitude/Longitude: 21.32° North, 157.93° West, Time Zone from Greenwich: -10
Data Source: TMY3 911820 WMO Station Number, Elevation 6 ft
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Source: Archdaily.com
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Daylighting parametric study of window configuration

Source: Tuan Tran ©
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Source: Complete Energy
http://completeenergy.co.uk/blog/building-information-modelling-bim/
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1st Prize at Design Optimization Competition 2012 awarded to Tran Tuan from the School of Architecture at University of Hawaii at Manoa, USA

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Lighting control study with Radiance simulation

Source: Tuan Tran ©
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Airflow analysis around Keller Hall, UHM’s campus using STAR-CCM+

Source: Research on progress by Environmental Research and Design Lab (ERDL) ©
Thermal Comfort Studies

AARTHI PADMANABHAN, D.Arch
Postdoctoral Fellow
Environmental Research and Design Laboratory
UHM’s School of Architecture
Dean William Chismar (Sinclair Outreach office): Request to propose strategies for improving thermal comfort

i. Within the office space
ii. Within the personal workstation of office occupants
Wireless data loggers

Anemometers and temperature sensors

Sensors and Data loggers: Proposed

- Anemometer (wind speed) = 4
- Dry bulb thermometer (air temperature) = 1
- Surface (roof) temperature = 2
- Globe thermometer (radiant temperature) = 3 with shield, 10 regular
- Temperature/Relative humidity = 2
- Modlet (Electrical equipment) = 10
- CO2 meter (to measure CO2 variances) = 1
- Infrared gun = 1
- Decibel (sound level) meter = 1
SENSOR ANALYSIS

Psychrometric chart

tdb 29.0 °C
rh 30.5 %
Wa 7.6 g w/kg da
twb 17.3 °C
tcp 9.8 °C
h 19.4 kJ/kg
4. What is your impression of the improvement in comfort between your own workstation and this test station? "The test station is ...."
   - A lot more comfortable
   - A bit more comfortable
   - About the same
   - A bit less comfortable
   - A lot less comfortable

5. Please test this ceiling fan at low and high fan speeds. Are you able to find a fan speed that makes you comfortable?
   - Yes
   - No

If yes, at that comfortable fan speed, is the air movement around the desk acceptable?
   - Yes
   - No
What's in the future for ERDL??

Psychophysiology