“High Performance Buildings Research in Architectural Engineering”

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Living Building

• Landscape
• Net-zero energy consumption (energy efficiency, advanced technology, smart systems integration, reconfigurable?)
• Comfort – occupants?
• Monitoring?
• Control of solar heat gains and daylighting (active windows and blinds)?
• Mechanical systems?
Architectural Engineering at Purdue

• The Architectural Engineering emphasis area is focused on **integrated design and operation of buildings**

• It includes all engineering aspects related to the built environment - mechanical systems (HVAC), electrical and lighting systems, building envelope, indoor environment

• **Multi-disciplinary Research and Education**
Architectural Engineering Emphasis Area

Structures

Geotechnical

Construction

ArchE focus

HVAC

Energy modeling

Heat/mass Transport

Lighting, Electrical

Building envelopes

Renewable energy

Systems integration
Architectural Engineering Courses at Purdue

Architectural Engineering
CE 311

Building envelope design and thermal loads
CE 413 – ME 497

Building Mechanical and Electrical System Design
CE 414 – ME 497

Lighting and Daylighting in Buildings
CE 513

Building Controls
CE 514 – ME 597

Building Energy Audits
CE 515 – ME 597

Sustainable Building Design, Construction and Operation
CE 597

Analysis of Thermal Systems
ME 518

Indoor Environment Analysis and Design
ME 502

Solar Energy Engineering
ME 597

Noise and Acoustics
ME 413

Thermal Analysis of Buildings
CE 697

Airflow Modeling in the Built Environment
CE 697
Architectural Engineering Labs - Bowen

Operable window

Spandrel panel
Center for High Performance Buildings at Herrick Labs
Energy Efficient Buildings Hub

• OVERALL GOAL: To reduce annual energy use in the commercial buildings sector in Greater Philadelphia by 20 percent by 2020.

• VISION: To design, demonstrate and deploy market proven solutions in the ten-county Greater Philadelphia region so that the buildings sector accomplishes its full potential for ongoing energy efficiency.

• MISSION: Enable the EEB Hub goal through informed people, validated information, and proven technologies.
Research Interests

• Integrated modeling, testing, design, analysis, and control of advanced building systems
  – Expertise on coupled thermal and airflow modeling and simulation

• Current research projects
  – Mixed-mode cooling in buildings
  – Building-integrated Photovoltaic-thermal systems, BIPV/T
Mixed-Mode Cooling

When outdoor conditions are appropriate ...

- Corridor inlet grilles and atria connecting grilles open;
- Atrium mechanical air supply flow rate reduced to minimum value, corridor air supply units close;
- Atrium exhaust vent open;

Need for intelligent (coordinated model predictive) control strategies.
# Model predictive control (MPC) for mixed-mode buildings

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<thead>
<tr>
<th>Cases</th>
<th>Design Parameters</th>
<th>Optimal NV Flow Rate (m³/s)</th>
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<tbody>
<tr>
<td></td>
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<td>20:00</td>
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<tr>
<td>1</td>
<td>Atrium floor thickness 0.4 m, 60% glazing without shading (S)</td>
<td>0.125</td>
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<tr>
<td>2</td>
<td>Atrium floor thickness 0.1 m, 60% glazing without shading (S)</td>
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<td>3</td>
<td>Atrium floor thickness 0.05 m, 60% glazing without shading (S)</td>
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<td>4</td>
<td>Atrium floor thickness 0.4 m, 60% glazing with shading (S)</td>
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<td>5</td>
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### Phase Change Materials?

![Graph showing cooling load and operative temperature over time for different cases.](image)
MPC for mixed-mode buildings

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PV/T Systems Integrated with Solar-Air Collectors

Key concepts:
- Thermal management and heat recovery
- Combined thermal/electrical efficiency
- End energy-use (building energy systems integration)
Particle Image Velocimetry (PIV)

Adapted from Dantec Manual
Building-Integrated Photovoltaics

Lumped parameter model