Impact of the natural ventilation in a bay of the IW on cooling and ventilation energy requirements for a typical summer in Pittsburgh

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PURPOSE OF THE PROJECT

- Extend the previous studies : validation and improvement of the TRNSYS/COMIS model

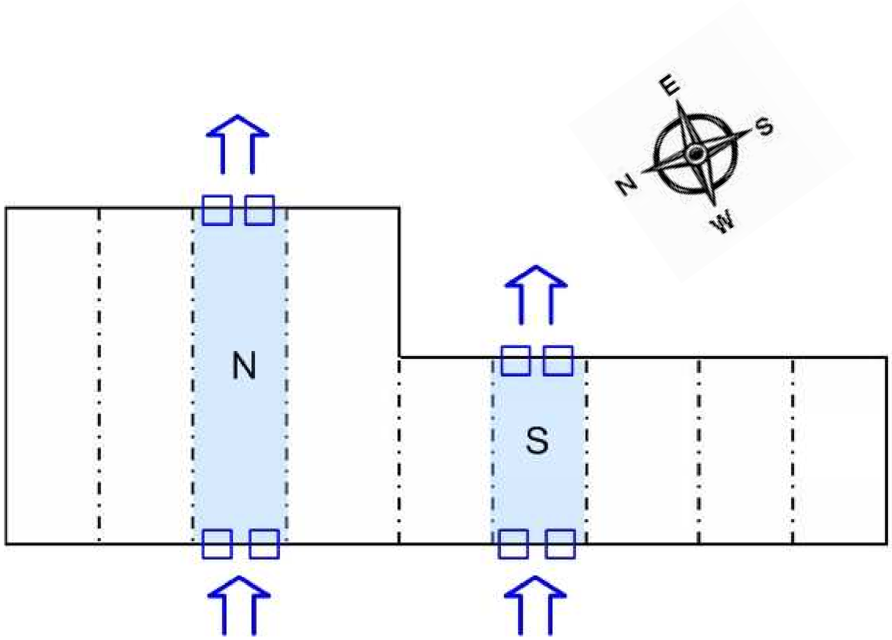
- Define control strategies for the window opening

- Predict the system performance to meet the cooling and ventilation requirements

- Determine the most efficient control strategy to maximize energy saving, ensure thermal comfort and avoid condensation in IW

CONTENTS

1. PRESENTATION OF THE STUDY



Cross ventilation

Modeling assumptions

<u>Zone :</u>
- One bay (south or north) of IW (Pittsburgh, PA)
- 2 windows on each façade (E&W)
- Adiabatic walls (N&S)

<u>Occupancy</u>
- 6 persons max.
- Zone occupied from 7:00 AM to 8:00 PM (thermal comfort required during this period)

<u>Window opening:</u>
- Two positions : maximum opening / close
- 4 windows opened at the same time

<u>Cooling system:</u>
- Fan coils (T set point : 22°C with a nighttime setback)

<u>Ventilation system:</u>
- Semco unit (Tset point : Tin / RH set point : 50%)

2. TRNSYS-COMIS model

- **TRNSYS (TRaNsient energy SYstem Simulation)**
 Flexible tool designed to simulate the transient performance of thermal energy systems
(developed by SEL, CSTB, TESS, TRANSSOLAR)

- **COMIS (Conjunction Of Multizone Infiltration Specialists)**
Multizone Air Flow and Contaminant Transport Model
(developed for IEA Annex 23, maintained by CSTB, EMPA, LBNL)

➢ **<u>TRNSYS-COMIS model :</u>**
dynamic thermal building model with an integrated ventilation model

3. CONTROL STRATEGIES

- Classical controls based on :
  - ✓ Temperature (Control A)
  - ✓ Temperature & Humidity (Control B)

  (Several on/off differential controllers with hysteresis)

- Different thresholds used for the controls

- Programmed in Fortran as a new TRNSYS component

Summary

<table>
<tr><th rowspan="2">Control strategy</th><th rowspan="2">Schedule</th><th colspan="2">Building loads</th><th colspan="2">Ventilation loads</th></tr>
<tr><th>sensible</th><th>latent</th><th>sensible</th><th>latent</th></tr>
<tr><td>Base case</td><td>[O] No natural ventilation</td><td>Fan coils</td><td>Semco unit</td><td colspan="2">Semco unit</td></tr>
<tr><td rowspan="2">Control A (T)</td><td>[N] nighttime natural ventilation</td><td rowspan="2">Fan coils / opening windows</td><td rowspan="2">Semco unit</td><td rowspan="2" colspan="2">Semco unit</td></tr>
<tr><td>[D&N] daytime and nighttime natural ventilation</td></tr>
<tr><td rowspan="2">Control B (T&RH)</td><td>[N] nighttime natural ventilation</td><td rowspan="2">Fan coils / opening windows</td><td rowspan="2">Semco unit / opening windows</td><td rowspan="2" colspan="2">Semco unit</td></tr>
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</table>

Control A = Influence of the minimum outside air temperature (Tout_limit) on the system performance and thermal comfort

Control B = Influence of the water temperature in the mullions (Tmullions) on the system performance and thermal comfort

4. SYSTEM PERFORMANCE

Bay in South

	Energy (kWh)			Thermal comfort (% of time in the comfort zone)		Hours of opening windows
Case	**Sensible**	**Latent**	**Total**	**Occupied**	**Unoccupied**	
Base case	*4,541*	*2,137*	*6,679*	*0.88*	*0.74*	*0*

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Control Temperature						
[N], Tout> 17C	15.0	*-184*	*-48.7*	0.83	0.38	525
[N], Tout> 15C	21.0	*-205*	*-51.5*	0.77	0.36	705
[N&D], Tout>17/19C	18.0	*-219*	*-57.8*	0.77	0.36	620
[N&D], Tout>15/19C	23.3	*-240*	*-60.9*	0.72	0.29	787

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Control Temperature and Humidity						
[N&D], Tout>17/19C, DP<12C	14.2	*-4.8*	8.9	0.88	0.54	468
[N&D], Tout>17/19C, DP<14C	20.9	*-1.0*	13.9	0.84	0.49	733
[N&D], Tout>17/19C, DP<15C	26.1	*3.3*	18.8	0.78	0.45	950
[N&D], Tout>17/19C, DP<16C	33.8	*11.0*	26.5	0.73	0.38	1255
[N&D], Tout>17/19C, DP<18C	45.8	*32.6*	41.6	0.59	0.29	1811

4. SYSTEM PERFORMANCE

The IW and the climate **are not ideal** for the natural ventilation:
-light thermal mass
-location of the windows
-not enhanced use of the stack effect
-High humidity in the outside air

Nevertheless, **decrease the total energy demand** : **14% of energy savings** (to maintain the thermal comfort during 84% of the occupied period) both in North and South bays : around 1,000 kWh per bay per summer

The use of the hybrid ventilation does not impact much the **cooling peak** (around 3.1kW – South bay / 3.4kW North bay).

The natural ventilation provides **required ventilation**.

5. FURTHER RESEARCH

Precision of the previous results can be improved thanks to:
✓ Measurement of the pressure coefficient Cp (to characterize the air tightness of the IW façade)
✓ CFD modeling (to study the air flow pattern in the IW)

Exercising the model in its current form:
✓ Increasing the thermal mass of the building
✓ Decreasing the time step between two control decisions (from 1 hr to 45 min or 30 min)
✓ Defining additional opening position of the windows

Additional extensions of the model:
✓ Improving the control strategy to open the windows (optimum or predictive control)
✓ Using fan assisted natural ventilation
✓ Implementing the solar shading control with the ventilation control

Additional research:
✓ Economical effect on energy consumption based on the electricity consumption of the fan coils and the Semco.
✓ Develop a modular model that can be used for the ITEST project

1 - Presentation of the study
2 - TRNSYS/COMIS model
3 - Control strategies
4 - System performance
5 - Further research

QUESTIONS ?