Designing natural ventilation for thermal comfort in buildings
Energy Use In Buildings

Source: Baker and Steemers
Building designed for outflow through stacks

- **Plant Store**
- **Ceilings Exposed Thermal Mass**
- **Ventilation Tower**
- **Warm Atrium**
- **Thermal Mass**
Complex Spaces – Houghton Hall
Atrium peak temperatures follow exposure to sun

Region near/within atrium hotter than desk area under exposed concrete \(\rightarrow\) benefit of thermal mass
Temperature Measurements

3-21 July Average temperatures

Main floor temperatures less than outside and buffered by thermal mass…
but still rather warm mid-July
Temperature Measurements

Warm inside again in early August
Temperature Measurements

15Aug-10Sept Average temperatures

Cooler after mid-August
Survey Results

Survey Results

- **Thermal Comfort**
  - 1c: 3.27
  - 3g: 2.93
  - 7: 4.58

- **Indoor Air Quality**
  - 5: 3.08
  - 4: 2.76

- **Personal Control**
  - 8: 5.01
  - 10: 4.32

- **Overall Health**
  - 4: 5.13

- **Overall Comfort**
  - 5: 4.17

**Rating Scale:**
- Average responses & standard error of the mean

**Survey Results:**
- Spring: 26 responses
- Summer: 24 responses
- Fall: 44 responses
- Winter: 40 responses

AVERAGE RESPONSE RATE > 50%
CONFIDENCE LEVEL FOR STANDARD ERROR 'p' = 0.05
Can we improve performance?
Range of time lag for building to reach max or min temp
Buffer for max temp 1-3 hours
Maximising Effectiveness of Thermal Mass
Air Flow Results

- Hot and still day (06/08/03)
- Fans are operating all day
- All windows open
Air Quality

Measurements show fresh air supply well in excess of minimum required

![Bar Chart]

Air supply (l/spp)

- Houghton Hall: 43-60
- Required: 8
Night Time Operation

- Limited number of trickle vents open

Upper part of atrium (2nd floor)

outside

Second floor

Temperature/C

Time

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1. Opportunity to use cool air from outside during night **even more effectively** to reduce building temperature

2. Reduce window openings during summer day to **maximise benefit of thermal mass**
Contact Theatre, after renovation
BB101 Standards
120 hours for which $T_{room} > 28^\circ$C
$(T_{room})_{\text{max}} = 32^\circ$C
$(T_{room} - T_{\text{external}})_{\text{max}} = 5^\circ$C

Belvoir High School
0 hours for which $T_{room} > 28^\circ$C
$(T_{room})_{\text{max}} = 27.5^\circ$C
$(T_{room} - T_{\text{external}})_{\text{max}} = 2.3^\circ$C
Internal Comfort

Priority School Building Programme

Making sense of the new Priority School Output Specification from the Education Funding Agency. How is the output specification different from previous guidelines, how do the standard school designs meet the output specification and how Breathing Buildings can help you model the ventilation system energy use in IES.
Hybrid Designs
Summary

- Natural ventilation low energy
- Exposed thermal mass
- Fan driven ventilation not “free cooling”