Displacement Ventilation

Basics, Advantages, and Case Studies

Barry J. Stamp, PE, LEED AP

Presentation Highlights:

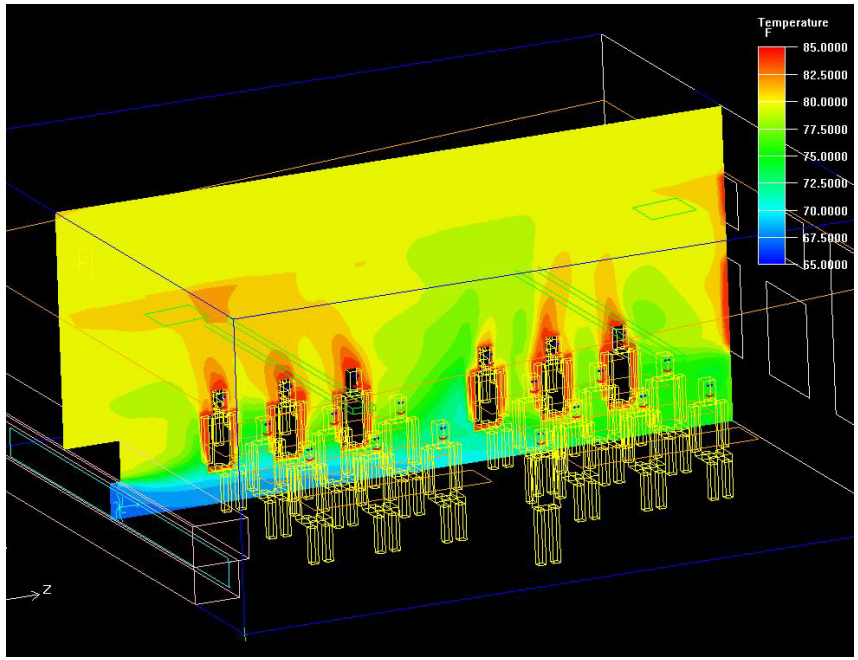
- Displacement Basics
- Design Basics
- Advantages
- Case Studies
- Q & A

Displacement Basics

- Ways to deliver conditioned air:
  - ✓ **Mixing** – air delivery resulting in induction of room air and mixing.
  - ✓ **Laminar** – Directional air delivery at high volume.
  - ✓ **Displacement** – air delivery at the floor level without mixing.

Displacement Basics

- Air flow relies on **natural** convective air movement caused by buoyancy forces.
- Conditioned air is delivered to the space at floor level at a low temperature differential.



Design Basics

- Zone cooling load: Emphasis is on the **occupied** zone of the space.
- **Each component** of the total space cooling load is addressed as a function of its impact on the occupied zone:
  - ✓ Occupants, equipment, task lighting
  - ✓ Solar / Envelope
  - ✓ Overhead Lighting

Design Basics

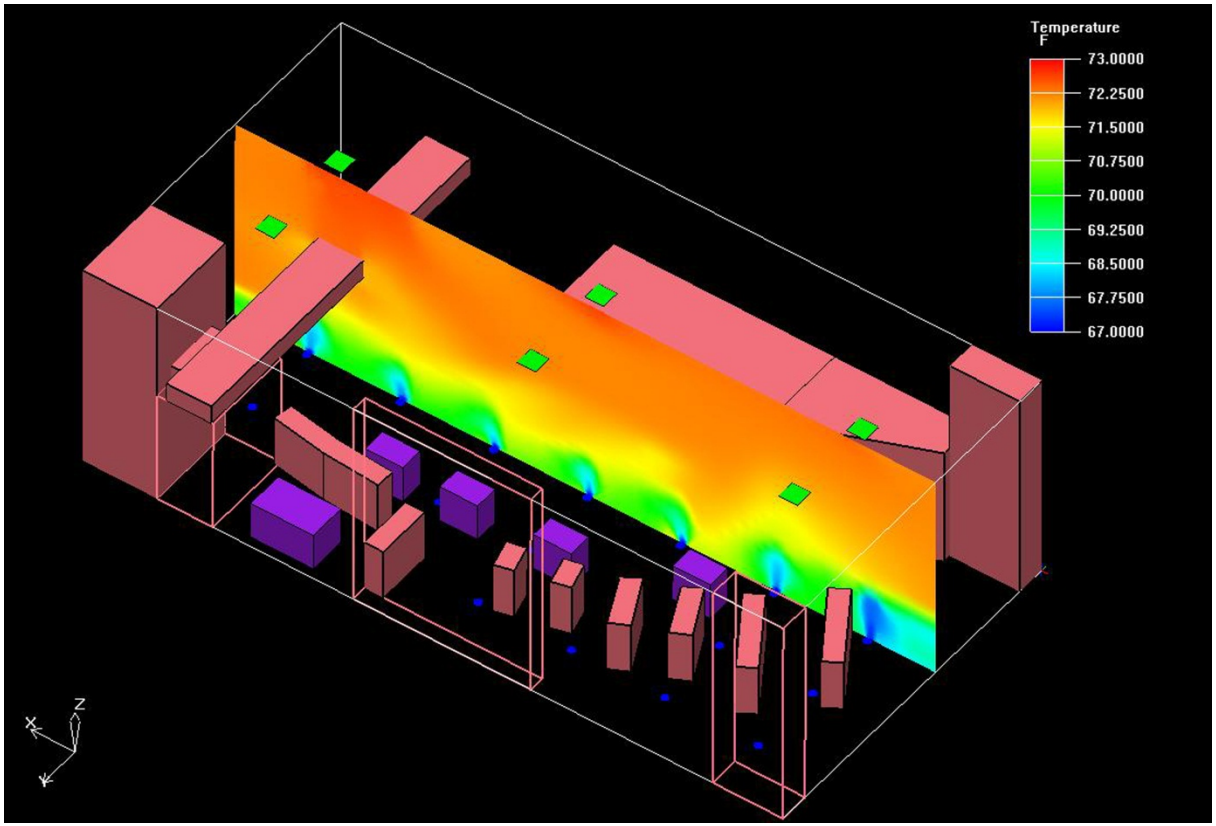
- From ASHRAE Research*: The occupied zone heat gain contributions are:
  - ✓ 13.2% of overhead lighting
  - ✓ 29.5% of occupants, task lighting, equipment
  - ✓ 18.5% of solar / envelope

*Office, classroom and workshop applications

Design Basics

- Supply air temperature must be held within 10-degrees of set point.
- HVAC equipment will still be sized for the total cooling load.
- Air within the space will stratify, and the return air temperature may be several degrees higher than the set point temperature.

Design Basics



Room temperature stratification

Design Basics

- When is Displacement not a good fit?
  - ✓ Low ceiling heights
  - ✓ High heating loads
  - ✓ Applications that require directional air flow

Design Basics

- Heating with displacement ventilation:
  - ✓ Heating load must be sufficiently low to be able to heat the space with low delta-T.
  - ✓ Morning warm-up can be a challenge.
  - ✓ Supplemental heating may be needed.
  - ✓ Special heating/cooling Dv diffusers are available.

Advantages

Displacement ventilation results in improved:

- Comfort
- Indoor air quality
- Acoustics
- Energy efficiency
  - ✓ Reduced fan motor loads
  - ✓ Refrigeration systems operate more efficiently
  - ✓ An expanded economizer window
  - ✓ Reduction in OA delivered

Case Study: Classroom

- Questions:
  - ✓ What is the comfort condition in the seating area?
  - ✓ How does the T-stat temperature relate to the seating area temperature?
  - ✓ How much cooling capacity is lost through an open door?
  - ✓ What is the cause of a momentary temperature bump seen in the afternoons?

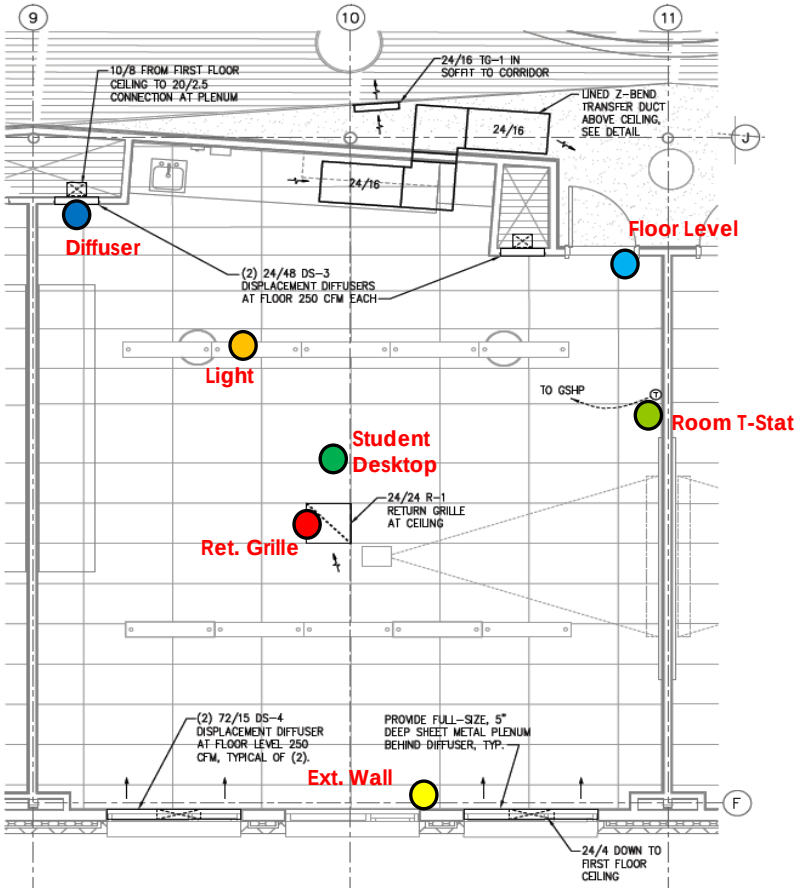
Case Study: Classroom

- South-facing classroom:
  - ✓ Room equipped with view and daylight windows.
  - ✓ Student seating area for 25-30 students.
  - ✓ Dv supplied at floor level along corridor wall and along exterior wall (less than 35 FPM)
  - ✓ Ceiling is sloped upward toward perimeter wall and upward toward interior tubular skylights.

Case Study: Classroom

- Data Logging Sensor Placement:
  - ✓ Diffuser face
  - ✓ Floor level near classroom door
  - ✓ Student desktop in middle of room
  - ✓ Room T-stat location
  - ✓ Between exterior windows
  - ✓ Under-side of pendant light
  - ✓ At ceiling return air grille

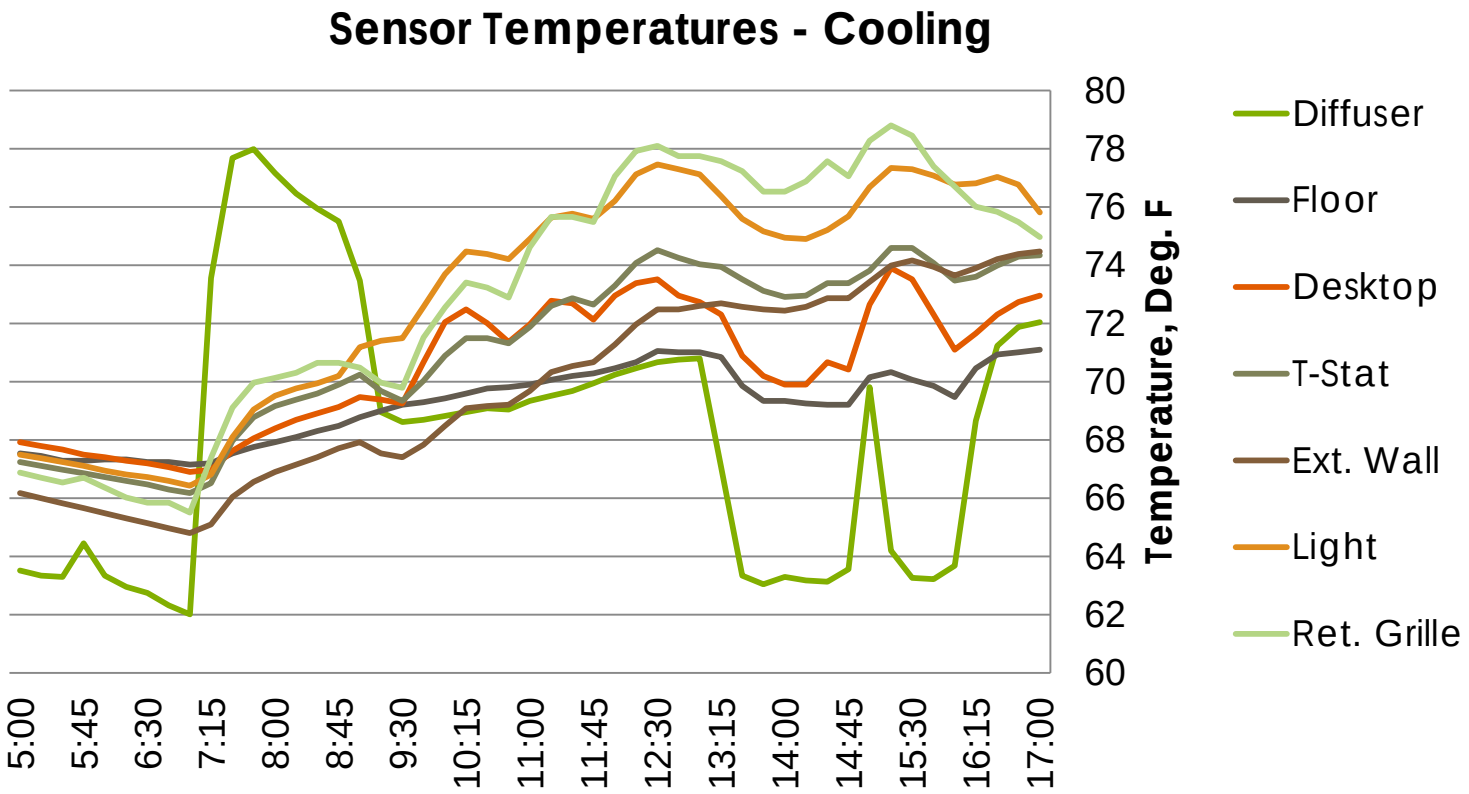
Case Study: Classroom



Case Study: Classroom

- Cooling Operation:
  - ✓ Sunny weekday with full student population
  - ✓ January day with low morning temperature of 24-degrees F and a high temperature of 63-degrees F
  - ✓ Near maximum solar gain – low solar angle

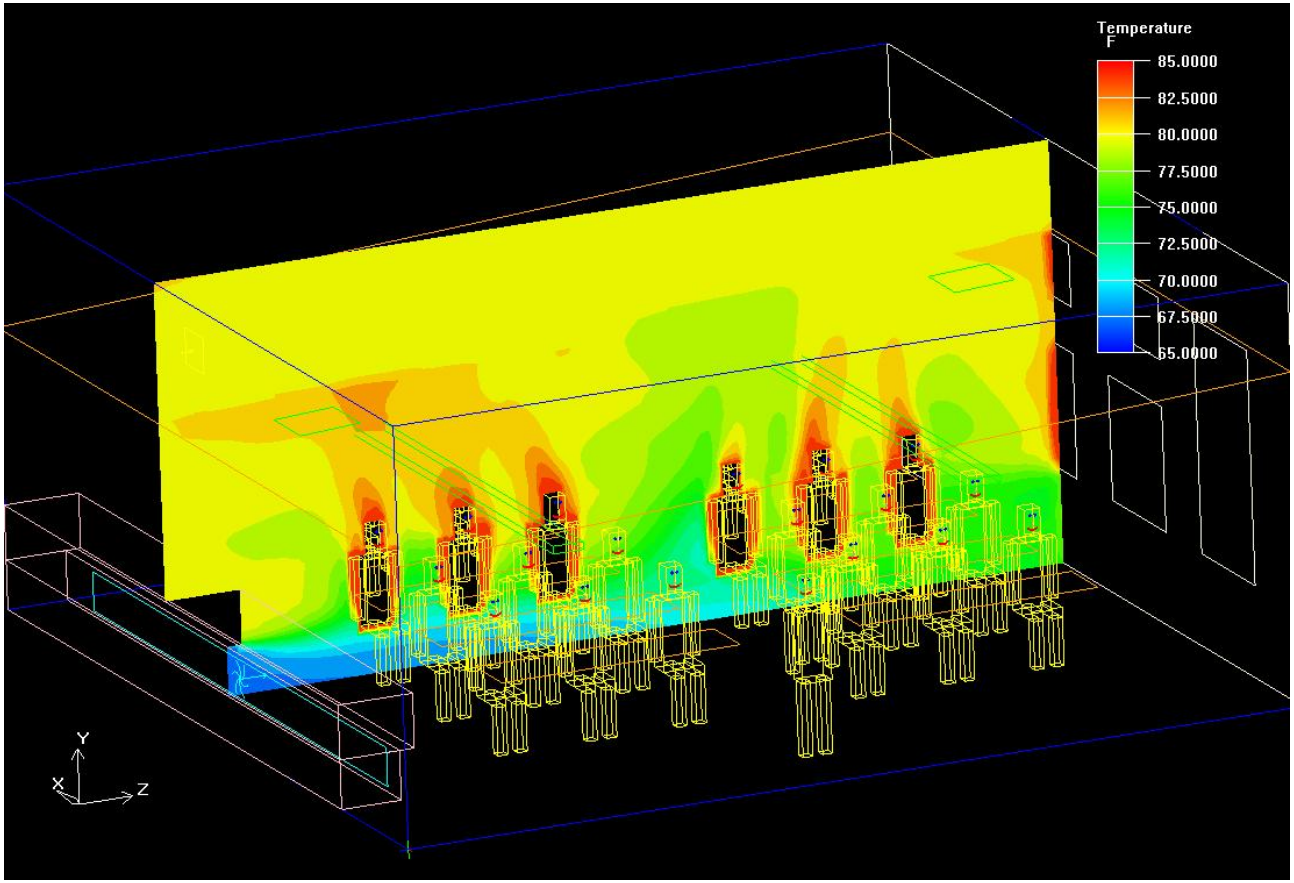
Case Study: Classroom



Case Study: Classroom

- Cooling Observations:
  - ✓ Despite relatively high Delta-T, the MWU appears to be effective.
  - ✓ Room stratification approaches 10-degrees F.
  - ✓ Student desktop temperatures are 1 to 3 degrees F lower than sensor temperature.
  - ✓ Floor temperature is cool, and only dropped slightly during cooling operation.
  - ✓ Good SA penetration into the student seating area.

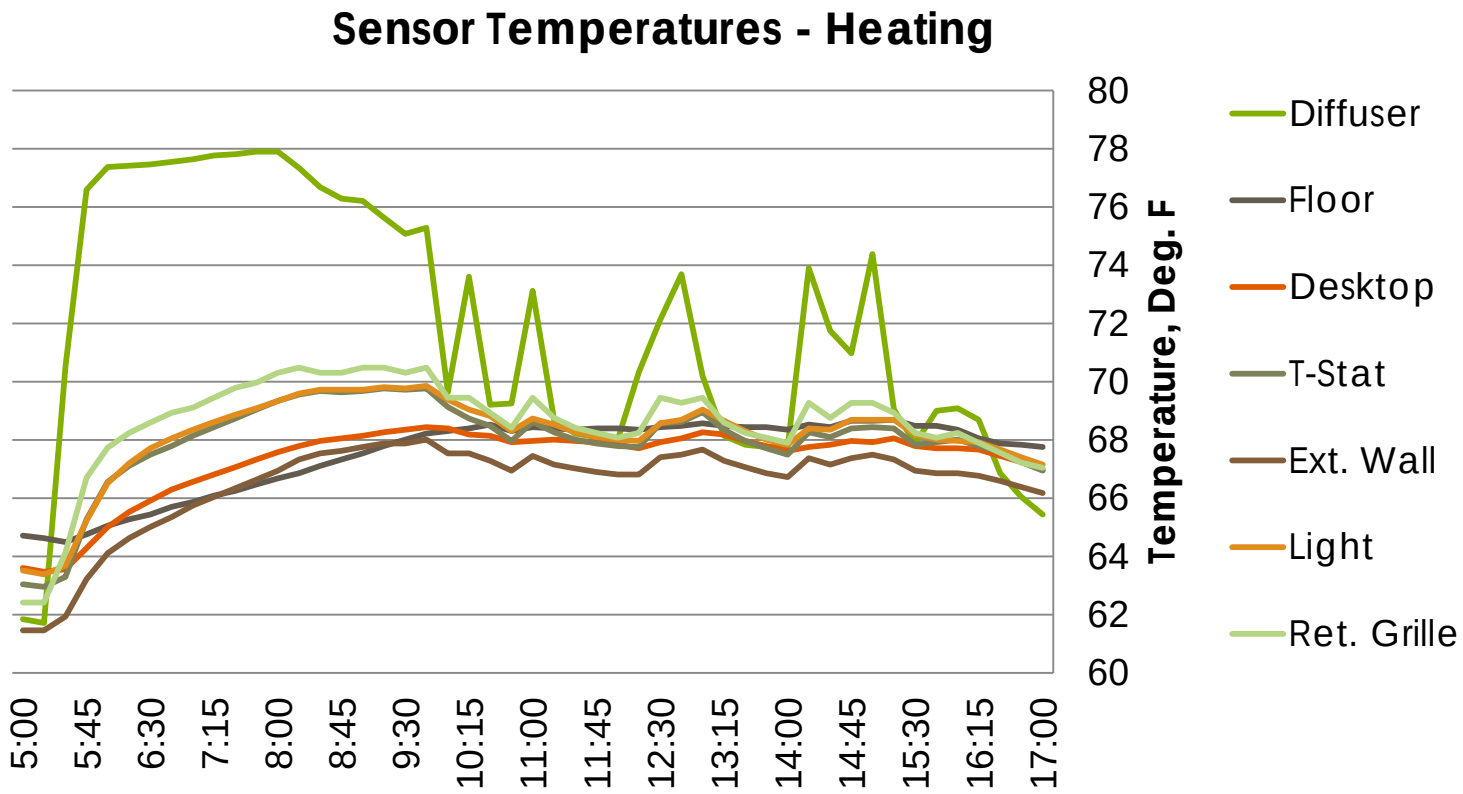
Case Study: Classroom



Case Study: Classroom

- Heating Operation:
  - ✓ Overcast weekday with full student population
  - ✓ 68-degree set point
  - ✓ January day with low morning temperature of 12-degrees F and a high temperature of 26-degrees F
  - ✓ Near zero solar gain

Case Study: Classroom



Case Study: Classroom

- Heating Observations:
  - ✓ MWU SAT is higher than desired, but effective. Warm air does not immediately rise to the ceiling.
  - ✓ Room stratification is nearly non-existent.
  - ✓ Exterior wall temperature is lowest reading, reflecting room cooling from exterior.
  - ✓ Good SA penetration into the seating area.

Case Study - Conclusion

- Displacement ventilation performance is as envisioned.
- Room air stratification is close to the expected range in the cooling mode.
- Heating mode operation is better than expected.
- Airflow penetration into the seating area is very good.

References:

- System Performance Evaluation and Design Guidelines for Displacement Ventilation, ASHRAE 2003
- ASHRAE Fundamentals Volume, 2010
- ANSI/ASHRAE Standard 62.1-2010, Ventilation for Acceptable Indoor Air Quality
- Air Device Manufacturer Design Guidelines and catalog data

- Thanks to Eaton Electrical Services Energy Solutions Group

Questions?

Thank You!

Barry J, Stamp, P.E., LEED AP
bstamp@sbengr.com