Challenges and Failures in Green Building Design Using Under-Floor Air Distribution

Ken Urbanek, PE, HBDP, LEED AP
Director of Engineering

MKK CONSULTING ENGINEERS, INC.
50 years and counting!
Agenda

- UFAD Overview
- Challenges / Failures
- Steps for a Successful Implementation
- Case Studies
UFAD Overview
UFAD Overview

- Traditional Overhead HVAC System

(Image: Center for the Built Environment)
UFAD Overview

- Under-Floor Air Distribution (UFAD) HVAC System

(Image: Center for the Built Environment)
UFAD Overview

- **UFAD requires an access floor, which is:**
  - Raised floor on top of the structural system
  - Provides space for: electrical, low voltage and a cavity for UFAD
**Recommendation:**
- Use access floor for distribution of power and low voltage systems
- AND where you have an environment that has a high occurrence of change (occupant churn)

**IF** the two criterion are met then yes consider providing UFAD.

**Recommendation is to not use an access floor with UFAD for just the HVAC benefits.**
UFAD Benefits, Theoretically:
- User operability / thermal comfort control
- Space Acoustics (reduced HVAC system noise)
- Increased Indoor Air Quality
- Energy Efficiency
  - Reduced airflow energy use
  - Reduced pressure energy use
  - Increase plant efficiency (higher RAT and higher DAT)

Access Floor Benefits
- Spatial Characteristics (higher ceilings in certain cases)
- Spatial Flexibility (occupant churn)
• User operability / thermal comfort control
• A UFAD system can typically provide many more controllable zones than a traditional system.
• **UFAD Benefits:**
  • Delivers conditioned air to the occupied zone rather than the entire space, thus reduced supply airflow
Challenges & Failures
Challenges & Failures

- **Plenum Integrity, aka LEAKAGE!**
Challenges & Failures

• Plenum air leakage with UFAD

“The construction of an airtight plenum requires strict coordination of **TEN TO TWELVE TRADES** and special construction techniques that have not yet been developed for concrete, masonry, drywall, millwork, sealant and joint specialists, RAF installers, carpenters, sheet metal, plumbing, electrical, communications, etc.”

Challenges & Failures

- Plenum Integrity, aka LEAKAGE!
Challenges & Failures

- Plenum Integrity, aka LEAKAGE!
Challenges & Failures

• **Associated Problems**
  • Over cooling of the space as a result of over airing
  • Under cooling of the space as a result of under airing (remote spaces)
  • Breakdown of space stratification; air short cycling
  • Excessive fan energy to compensate for leakage
  • Excessive supplemental system energy to condition higher airflows (chillers, cooling towers, etc...)
Challenges & Failures

• **Thermal Decay**
  • **Energy Gain = Increased Supply Air Temperature**

(Image: Center for the Built Environment)
• **Thermal Decay**
  • Variable Supply Temperature; from close inlets to remote outlets
  • Difficult to satisfy all spaces on account of temperature variations
Challenges & Failures

- **Thermal Decay w/Semi Decoupled Perimeter System**

(Image: Center for the Built Environment)
Challenges & Failures

- Additional Challenges
  - Humidity Control
  - Outlet Placement Coordination
  - Plumbing Systems on the Access Floor & Water Control
  - Plenum Rated Components
  - User Operation & Maintenance – Leakage
  - User Operation & Maintenance – System Operation
  - User/Occupant Education
Steps for a Successful Implementation
Steps for a Successful Implementation

- Reducing thermal decay
  - Limit distance between UFAD inlets and remote outlets
  - Limit the use of semi-decoupled perimeter systems
Steps for a Successful Implementation

- Limit Distance On Semi-Decoupled Perimeter System

(Image: Center for the Built Environment)
Steps for a Successful Implementation

- Consider Alternate Perimeter Systems
  - Chilled Beams / Baseboard
  - Variable Refrigerant Flow
  - Heat Pumps (Geothermal or Tower/Boiler)
  - Chilled Water / Hot Water Fan Coils
  - Central Ducted system (below floor or overhead)
Steps for a Successful Implementation

- Reducing plenum leakage - Address all the trades that may interact with the access floor
Steps for a Successful Implementation

- Reducing plenum leakage
  - There are numerous interactions with the access floor
  - Provide clear documentation on sealing the plenum, including clear details & specifications showing what is required of all trades
Steps for a Successful Implementation

- Reducing plenum leakage
  - Specify products that address sealing the under floor.
  - Don’t Rely on “seal penetration” statements
Steps for a Successful Implementation

• Reducing plenum leakage
  • Specify performance requirements
  • Use mock-up tests to check means & methods
Steps for a Successful Implementation

• Reducing plenum leakage
  • Strictly enforce details and specifications
  • Communicate the end goal to all parties involved: contractors, sub-contractors, owner, operators, etc…
  • Ensure buy-in of the philosophy across the board
  • The design team needs to work together to develop a quality level for the access floor plenum construction that the owner is expecting and that the contractor MUST be held to.

• Continuous communication
Case Studies
Case Studies

- Case Study #2 (from paper) – Denver, CO
Case Study #2 (from paper) – Denver, CO
- 300,000 sqft, 5-story commercial office building
- Chilled Beams & Hot Water Perimeter System
- LEED CS & CI - Platinum

Operational Issues of Note
- Extensive sun projection into building created issues with UFAD capacity
- Operators didn’t understand need for higher discharge air temp for UFAD, led to cold calls
- Variable occupant spaces not suited to manual control, i.e. conference rooms
Case Studies

- Case Study #3 (from paper) – Denver, CO
Case Studies

- Case Study #3 (from paper) – Denver, CO
  - 500,000 sqft, 22-story commercial office building
  - Semi-Decoupled Perimeter System
  - LEED CS & CI - Platinum
- Operational Issues of Note
  - Air highways minimized thermal decay and multi-story cascading thermal decay
  - High performance envelope reduced intense cooling at perimeter
  - Issues with furniture coordination….aka diffusers under cube walls/cabinets
Case Studies

- Case Study #4 (from paper) – Denver, CO
Case Study #4 (from paper) – Denver, CO

- 50,000 sqft, 2-story built-to-suit office building
- Variable Refrigerant Flow Perimeter System
- LEED NC – Gold

Operational Issues of Note

- Decoupled system eliminates problems with thermal decay and perimeter cooling
- Extensive sun projection into building created issues with UFAD capacity
Case Studies

- Case Study #4 (from paper) – Denver, CO
Questions?
Thank you!

Ken Urbanek, PE, HBDP, LEED AP
kurbanek@mkkeng.com