MAXMIZE DISPLACEMENT VENTILATION OPPORTUNITIES

GLUMAC DESIGN STRATEGIES



In Seattle, the **Amazon Headquarters** building, features an open air atrium that provides natural ventilation throughout the facility.

VENTLATION FOR OPTIMUM INDOOR AIR QUALITY

DISPLACEMENT VENTILATION

A passive approach to introducing fresh, cool air to maintain comfort and air quality. In the right environment, displacement ventilation can prove to be a cost-effective, sustainable solution.

Glumac continues to apply established MEP technologies like displacement ventilation in new and creative ways. In a commercial or institutional setting, these systems supply a "cool pool" of air in a space at floor level. Through natural buoyancy, the air – attracted naturally to heat sources such as people, computers, and lighting – warms up and rises gently while maintaining comfortable conditions for occupants. Typical system components include the air handling unit, environmental air space of 12 to 16 inches (0.3 to 0.4m), and diffusers mounted on either the wall, floor, or in the corners. In open office environments, these systems utilize raised access flooring to distribute air and facilitate cabling and power changes for areas with high turnover rates. Displacement ventilation also performs well in semi-conditioned spaces that feature high ceilings, such as building lobbies and atriums.

Auditoriums represent another successful application for Glumac designers. Here, theatrical lighting creates the

biggest space load, requiring that conventional overhead air systems produce additional cooling to counter the effects of heat gain from multiple light fixtures in addition to the heat generated by the audience during a performance.

Though designed to minimize acoustic levels, most traditional diffusers also do not create adequate air flow, so temperatures vary widely from seat to seat within an auditorium. Instead, supplying air at the floor level – between 63°F and 65°F/17.2°C and 18.3°C –stratifies temperatures in a space. For example: occupied zones, at six feet and below, remain at desired temperatures, approximately 74°F to 76°F/23.3°C to 24.4°C. The warm air then migrates upward with temperatures increasing to 85°F to 90°F/29.4°C to 32.2°C at the ceiling, where it is then extracted along with the heat from theatrical lighting, etc.

UNDER FLOOR AIR FOR THE OFFICE ENVIRONMENT

The use of raised access flooring to distribute underfloor air provides an affordable solution for reconfiguring office layouts in open floor plans. In contrast to conventional ductwork schemes, electrical outlets and air outlets are relocated simply by unscrewing and moving floor tiles. Additional benefits of these systems include reduced energy consumption and greater flexibility for individual temperature control. While some occupants prefer a cooler space, others want it warmer; each floor diffuser therefore contains an adjustable air flow control so every occupant may increase or reduce the amount of cooling air in their space.

On projects without raised floors, Glumac promotes the use of vertical displacement diffusers – either placed in corners, as free-standing units, or mounted into walls and tied into the building's duct system. In each case, low velocity air is delivered across the space (lobbies and corridors, for example) by the displacement ventilation system, picking up heat from people and equipment as it rises to the ceiling.

AIR SIDE ADVANTAGES

Due to higher supply temperatures, displacement ventilation systems also take fuller advantage of a building's economizer cycle (the ability to cool with outside air), operating many more hours a year at 60°F to 65°F/15.6°C to 18.3°C – versus a conventional system that delivers air at 52°F to 55°F/11.1°C to 12.8°C. These devices, integrated into a central air handling system, bring in more outside air to heat or cool spaces and equipment while exhausting the return air. This "free cooling" approach can lead to significant energy savings. In San Francisco's climate, for example, 4,165 hours of the year fall below 55°F/12.8°C (with 980 of those hours being general work time, between 7:00 a.m. and 7:00 p.m. Monday through Friday). In addition, 7,671 hours of the year fall below 65°F/18.3°C (with 3,952 hours between 7:00 a.m. and 7:00 p.m. and 7:00 p.m. Monday through Friday).

PROCESS/TOOLS



The North American headquarters facility for Vestas, a worldwide leader in wind turbine manufacturer, is located in a renovated historic warehouse building in Portland, Oregon, and utilizes displacement ventilation, most notably with a central atrium that helps condition the office spaces.

BEFORE: VESTAS HEADQUARTERS DISPLACEMENT VENTILATION

- 1. outside air intake
- 2. air handlers
- 3. raised access floor
- 4. underfloor air distribution
- 5. floor diffusers
- 6. atrium with stack ventilation
- 7. skylight building relief with fan assist
- 8. HVAC return wall grill with sound trap

Simple Physics: Underfloor air distribution figures prominently in the LEED Platinum renovation of a Portland landmark for Vestas, a leading manufacturer of high-tech wind power systems. In the original HVAC layout, designers discovered return air inlets were placed too close to the perimeter, drawing heat from the skylight and creating excessive heat for upper floors. Glumac's computational fluid dynamic (CFD) models confirmed this.





AFTER: VESTAS HEADQUARTERS DISPLACEMENT VENTILATION

- 1. outside air intake
- 2. air handlers
- 3. raised access floor
- 4. underfloor air distribution
- 5. floor diffusers
- 6. atrium with stack ventilation
- 7. skylight building relief with fan assist
- 8. HVAC return wall grill with sound trap

CFD Solution: In Glumac's revised HVAC schematic, designers moved return air inlets close to the skylight to solve the heat buildup problem. Again, CFD modeling confirmed these changes would improve air distribution at target temperatures throughout interior spaces.





VESTAS HEADQUARTERS NIGHT COOLING

- 1. outside air intake
- 2. air handlers
- 3. raised access floor
- 4. underfloor air distribution
- 5. floor diffusers
- 6. atrium with stack ventilation
- 7. skylight building relief with fan assist
- 8. HVAC return wall grill

Air Change: Opening in 2012, the 172,000-square-foot (15,979-square-meter) office will utilize its extensive thermal mass and a night purge system as the predominant means of cooling within the central atrium and open work spaces across five floors.



a displacement ventilation scheme. For example, does the project feature an open office, with an expected high churn rate? How will space be used: does the building include large conference rooms with program areas open from 9 a.m. to 5 p.m., or are they operate late – or even 24/7? Designers also weigh the following points:

Higher discharge air temperatures: This approach calls for a completely different type of design thinking. Where conventional systems typically introduce air at a cooler 55°F/12.8°C to condition entire spaces, discharge air via displacement diffusers enters at a minimum of 63°F/17.2°C to condition only occupied spaces (up to six feet/1.8m); otherwise, lower temperatures may tend to draft down to ankle level and create an uncomfortable environment. Location (proximity to outdoor air temperatures and humidity): To dehumidify a space requires cooling the air to 55°F/12.8°C, so this technology is not well suited for humid climates without a return air bypass or a dedicated outside air system.

Decoupled systems: displacement technology works well in tandem with chilled beams/overhead radiant at the ceiling level. With this combination, displacement ventilation supports the base (or constant) loads of the space, while the overhead systems provide supplemental heating or cooling.

Environmental air space: For raised access floors, the

ideal design space for air movement varies from 12 to 16 inches/0.3 to 0.4m, depending on the floor plate. While there are exceptions, any less vertical space may require additional air handling units to move air effectively beneath the floor; like-wise, anything higher than 16 inches/0.4m may require seismic restraints according to code.

FURTHER DESIGN FACTORS

Beyond programming and structural considerations, cost becomes a critical factor in determining the feasibility of these systems. Raised floors, for example, cost \$5 to \$10 more per square foot to install (estimates vary according to vendor, type of flooring, grilles, etc.) than conventional overhead systems. However, the benefits may far outweigh the added expense in terms of improved ventilation efficiency and savings over time with high office churn rates.

In addition, underfloor systems studies consistently demonstrate improved personal comfort and better indoor air quality. While overhead ductwork promotes mixing of air throughout an office, distributing germs, dust and dirt, the "single pass" design of displacement ventilation systems – which condition only the occupied space as air rises up – can also mean higher productivity and fewer sick days. G