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turning air distribution upside down…
Underfloor Air Distribution

from the editor…
One of the "fallouts" of technology is increasingly savvy consumers. Armed with cellular phones, personal digital assistants, and wireless laptops, we're accustomed to immediate gratification. We also know that the seemingly infinite possibilities of digital controls mean that we need not content ourselves with "one-size-fits-all" products and services.

Ironically, it's standard practice to design comfort systems that create thermally uniform indoor environments. How long will it be before we can fine-tune our workspaces to satisfy individual preferences? Not as long as you might think. Low-pressure underfloor air distribution represents one way to give occupants greater control over their immediate environments.

Applied elsewhere in the world for many years, underfloor air distribution has made its way into a small but growing number of major U.S. office facilities. Will it become the next serious alternative to conventional overhead methods of air delivery? Time will tell.

Underfloor air distribution, or **UAD** in this publication, is of increasing interest to those who own or design office buildings. Some industry-watchers predict that as many as 35 percent of tomorrow's office buildings will include UAD systems.[1] Others question its practicality or readiness for widespread application.

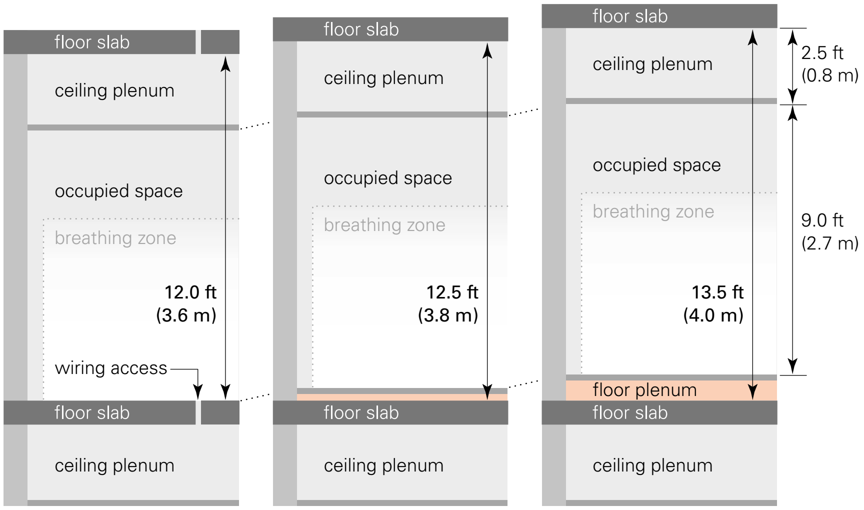
A brief review of underfloor air distribution will help us identify the advantages and difficulties of applying these systems. Let's start with the floor itself, because it's from there that the conditioned air is distributed.

Floor Choices

The architect or structural designer can choose between a traditional floor-on-slab; a slightly raised floor or a channeled slab to accommodate wiring; or an access floor, which is elevated enough to house wiring plus other utilities and equipment. See Figure 1.

With a traditional **floor-on-slab**, wiring for power and communications and plumbing for sprinklers are usually located in a plenum above a suspended ceiling. Holes are drilled through the

Figure 1. Types of Floor Systems



Floor-on-Slab

Raised Floor
0.5 ft (0.2 m) floor plenum

Access Floor
1.5 ft (0.4 m) floor plenum

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[1] I. Krepchin, "Underfloor air systems gain foothold in North America," *E Source Report* ER-01-1 (January 2001), Boulder, CO: Financial Times Energy, Inc.

concrete slab to accommodate wires for the floor above.

Raised floors, which are elevated 3 to 6 inches (7.5 to 15 cm) above the slab, and **channeled slabs** provide electrical and utility service on top of or within the slab. Although these techniques increase the initial cost of the floor, they usually reduce wiring-related expenses because slab drilling is unnecessary.

With an **access floor**—which is 12 to 18 inches (30 to 46 cm) or more above the slab—all wiring, utilities, and equipment such as junction boxes, outlet devices, and small terminal units are "sandwiched" between the access floor and the concrete slab below.

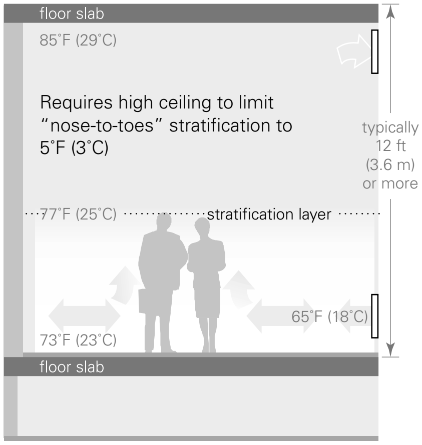
Like raised floors and channeled slabs, an access floor is more expensive to install and can be partially subsidized by simplifying the installation of wiring and utilities. The premium for installing an access floor alone may be $5 USD/ft^2 or more, but the *overall* premium (which varies widely[2]) may be only $3 USD/ft^2 when all of the initial costs for the building are considered.

Why would a cost-conscious owner or developer opt to pay the premium for an access floor? To reduce the expenses incurred by subsequent changes in the office layout. Surveys show that more than 40 percent of the occupants in modern office buildings relocate at least once each year.[3] Annual occupant relocation, quantified as **"churn" rate**, is increasingly common; it is also expensive, especially for high-tech businesses. In many cases, reducing churn-related expenses such as rewiring costs can repay the additional investment of installing a non-traditional floor.

Air Distribution Options

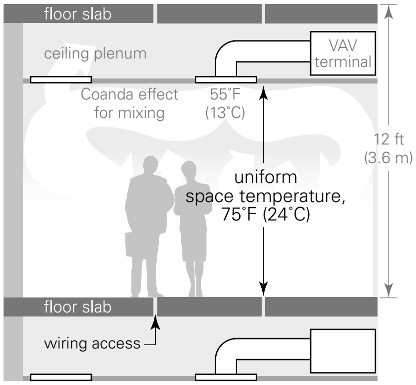
Traditional **overhead VAV distribution** (Figure 2) is used extensively in office buildings. Supply ducts, VAV boxes, and overhead diffusers—usually in an above-ceiling plenum formed by a suspended ceiling—distribute cold, 50°F-to-55°F (10°C-to-13°C) supply air to the spaces. This method of air distribution produces relatively uniform temperatures throughout the space because it induces significant mixing of space air with supply air. Return air leaves the space at approximately room temperature.

Figure 3. Displacement Ventilation



Displacement ventilation (Figure 3) is commonly used in industrial spaces, theaters, and other applications with very high ceilings. Diffusers, usually mounted low in sidewalls, release slow-moving, 65°F-to-72°F (18°C-to-22°C) air into the space; meanwhile, heat sources in the space induce local airflow from the floor toward the ceiling. Along the way the air stratifies into temperature layers, which become progressively warmer from the floor to the ceiling. Depending on the heat sources, airflow rate, and ceiling height, the air is 85°F (29°C) or more when it enters the return openings near the ceiling.

Figure 2. Overhead VAV Distribution



UAD systems represent a third choice, **"partial" displacement ventilation**. Floor-mounted diffusers release cool 63°F-to-68°F (17°C-to-20°C) air, which induces local circulation and causes partial mixing and relatively uniform temperatures from the floor to a height of 3 to 6 ft (1 to 2 m). See Figure 4 and the inset below. Above that point, the air temperatures stratify. At the return openings near the ceiling, the air temperature ranges from 80°F to 85°F (27°C to 29°C), depending on heat sources, airflow, and ceiling height.

Partial Displacement Ventilation

This *EN* only discusses floor-mounted diffusers; however, furniture-mounted diffusers can also be used to implement partial displacement ventilation. Such systems, which are described as *task/ambient conditioning (TAC) systems,* deliver supply air directly to the occupant/task area as well as to the ambient space. TAC systems are similar to UAD systems and deliver many of the same benefits. ■

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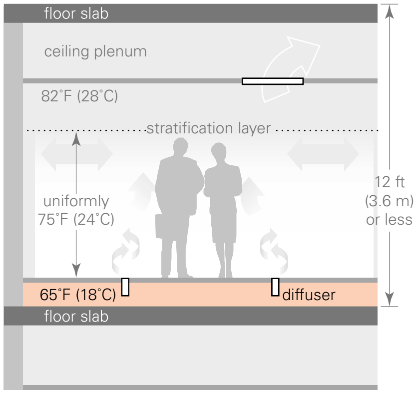
[2] F. Bauman and T. Webster, "Outlook for underfloor air distribution," *ASHRAE Journal* 43 no. 6 (June 2001): 18–27.

[3] International Facility Management Association (www.ifma.org), *Benchmarks I, II, III* (1991, 1994, 1997).

Figure 4. "Partial" Displacement Ventilation (Underfloor Air Distribution)



Approaches to UAD Design

Let's take a closer look at access floor systems with underfloor air distribution. Designers usually pick one of two approaches to distribute air from an access-floor system: neutral-plenum or pressurized-plenum.

Note: Due to high initial and operational costs, most designers avoid a third possible approach that ducts primary air to each floor-mounted diffuser.

In **neutral-plenum designs**, a central air handler delivers conditioned primary air to the floor plenum. From there, the air is delivered to the space by either of two types of floor-mounted diffusers: "passive" diffusers that are connected to fan-powered terminals or "active" (fan-powered) diffusers. Although the local fans increase the cost of installing and operating the system, they may be unavoidable if a leaky access floor or building envelope makes it difficult to pressurize the plenum.

When excessive leakage is not a problem, a **pressurized-plenum design** can be used. In this case, a central air handler delivers primary air to the floor plenum, pressurizing it to approximately 0.05 to 0.10 in. wc (12 to 25 Pa) above space pressure. Passive floor-mounted diffusers, either manually or automatically adjusted, deliver the plenum air to the occupied space.

The next section evaluates pressurized-plenum UAD systems serving spaces with relatively constant loads. (For this article, we chose to ignore underfloor air distribution in spaces with widely varying loads—perimeter zones and conference rooms, for example—because of the complexity of these applications.)

Potential Advantages

Some advocates claim that pressurized-plenum UAD systems offer several advantages over traditional overhead VAV systems. Following is a discussion of the benefits most commonly associated with these advantages.

Lower churn-related life-cycle costs. Most of the savings related to office reconfiguration result from the access floor, which lowers rewiring costs regardless of how the air is distributed. Can underfloor air distribution trim *additional* expense from "churn"? The answer depends on the type of relocation.

Cubicle rearrangements in UAD applications usually require the relocation of floor-mounted diffusers. By contrast, rearranging cubicles in a space with overhead VAV distribution seldom (if ever) affects the placement of ceiling diffusers. In terms of air distribution alone, then, UAD may actually *increase* the cost of cubicle-wall "churn."

Rearranging the walls of private offices is another matter. In this situation, underfloor air distribution avoids the expense of moving and rebalancing overhead ducts and diffusers.

Reduced floor-to-floor height. Often cited as an initial cost benefit of underfloor air distribution, removing the supply ducts, terminals, and diffusers from the ceiling can reduce overall plenum height, and may reduce slab-to-slab and total building height…perhaps by as much as 10 percent.[2]

Improved comfort. A combination of cold plenum air, low-induction floor-mounted diffusers, and reduced airflow can cause excessive (uncomfortable) stratification. However, direct control of supply airflow (a hallmark of most UAD systems) increases the degree of comfort that occupants perceive.[4]

To assure that a UAD application provides the promised improvements in individual thermal comfort, the design of the system must properly account for all relevant parameters, including vertical load distribution, diffuser throw, and floor temperature.

Improved productivity. As implied above, people express greater satisfaction with thermal comfort when they can control their immediate environment. Adjustable, floor-mounted diffusers contribute to occupant satisfaction because they allow at least *some* adjustment for individual preferences. Reducing or eliminating the distraction of thermal discomfort in a space increases the productivity of those who occupy it.

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[4] D.P. Wyon, "Individual microclimate control: required range, probable benefits, and current feasibility," *Proceedings of Indoor Air* 96, no. 1 (1996): 1067–1072.

Improved indoor air quality. Indoor air quality (IAQ) relates to contaminant concentrations in the breathing zone. Some studies report lower breathing-zone concentrations for UAD systems than for overhead VAV systems.[5] Here's why…

In overhead VAV applications, mixing disperses contaminants throughout the space. In UAD applications, contaminants "collect" near the ceiling outside of the breathing zone, so occupants breathe "cleaner" air. Given the higher air-change effectiveness (E_{ac}) of UAD spaces, proper space ventilation requires less outdoor airflow at the diffusers. (See "Air-Change Effectiveness, E_{ac}" on page 5.)

Reduced outdoor airflow. If better air-change effectiveness in UAD spaces means that each diffuser needs less outdoor air for ventilation, then it follows that the building ventilation system can condition less outdoor air and, therefore, will require less heating and cooling capacity. How much less? That depends. As the example in "Effect of Air Distribution on Ventilation Airflow" demonstrates, when air-change effectiveness increases from 0.95 (VAV) to 1.10 (UAD), system ventilation efficiency, *E,* at design conditions also improves—from 0.966 (VAV) to 0.991 (UAD), in this case.

Although the UAD system reduced both outdoor airflow and, therefore, the installed capacity required at the plant, the reductions are significantly less than one might expect. In multiple-space mixed-air applications, improving the air-change effectiveness in the space does *not* yield an equal improvement in system ventilation efficiency (or airflow reduction) at the outdoor air intake.

Note: System ventilation efficiency improves for UAD at design conditions, which can reduce the installed capacity *of the heating/cooling plant. For overhead VAV distribution, system ventilation efficiency improves at part load, which can reduce the required* operating capacity *if the system is equipped with proper ventilation-reset controls.*

Less fan horsepower. If we assume that UAD and overhead VAV systems require the same supply airflow at design conditions (see "Airflow" on page 5), then the absence of supply ducts, terminals, and runouts in a pressurized-plenum UAD system reduces the external static pressure on the supply fan. Less external static pressure results in the selection of a smaller motor (lower initial cost)…but does it also mean that UAD requires less horsepower (costs less to operate) than overhead VAV distribution?

Effect of Air Distribution on Ventilation Airflow

A simple example can help us determine how underfloor air distribution (UAD) affects the amount of outdoor air that must be brought into the building for proper ventilation, as compared to overhead VAV distribution. Assume that a three-space system is served by a central air handler. The system must comply with the "multiple-space" equation (6-1) from ASHRAE Standard 62–1999. Each space needs 1,000 cfm of supply air at the design condition, and the per-space outdoor air requirements are 125 cfm, 150 cfm, and 175 cfm, respectively.

Determining how much outdoor air must be brought into the system entails finding the diffuser (not breathing-zone) ventilation fraction, $z = V_o/(E_{ac} \times V_s)$, for each space, and then calculating the critical-space ventilation fraction (Z = largest z) as well as the average ventilation fraction, $X = \Sigma V_o/\Sigma V_s$, for the system.

Note: The air-change effectiveness of the space does not *affect the average ventilation fraction for the system, which is based on breathing-zone needs.*

Solving for system ventilation efficiency ($E = 1 + X - Z$) and total outdoor airflow, $V_{ot} = \Sigma V_o/(1 + X - Z)$, we find that the overhead VAV system requires 466 cfm while the UAD system requires only 454 cfm…about 2.6 percent less outdoor air than the VAV system.

System-Level Characteristics	VAV	UAD
Average breathing-zone ventilation requirement, X	0.150	0.150
Critical-space ventilation fraction, Z	0.184	0.159
Ventilation efficiency, E	0.966	0.991
Total outdoor airflow, V_{ot}	**466 cfm**	**454 cfm**

It's interesting to note that although underfloor air distribution improves the air-change effectiveness in each space by 16 percent (in this example), the system ventilation efficiency and total outdoor airflow required at the outdoor air intake only drop by 2.6 percent. The slight reduction of system-level outdoor airflow makes sense when we remember that any contaminants that escape the breathing zone recirculate at the air handler. ■

Per-Space Ventilation Characteristics for Example Three-Space System

	Supply Airflow V_s, cfm	Outdoor Airflow V_o, cfm	Air-Change Effectiveness, E_{ac}		Ventilation Fraction, z	
			VAV	UAD	VAV	UAD
Space 1	1,000	125	0.95	1.10	0.132	0.114
Space 2	1,000	150	0.95	1.10	0.158	0.136
Space 3	1,000	175	0.95	1.10	**0.184**	**0.159**
Totals	3,000	450				

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[5] D. Faulkner, W.J. Fisk, and D.P. Sullivan, "Indoor airflow and pollutant removal in a room with floor-based task ventilation: results of additional experiments," *Building and Environment* 30, no. 3 (1995): 323–332.

Air-Change Effectiveness, E_{ac}

The comparatively higher air-change effectiveness of a space that is served by UAD rather than an overhead VAV system reduces the amount of outdoor air that must be brought into the building. Consider the example below.

A space requires 150 cfm (75 L/s) of outdoor air within the breathing zone. If we assume an air-change effectiveness of 0.95 for overhead VAV distribution, then 150/0.95 = **158 cfm** (75/0.95 = 79 L/s) of outdoor air must reach the diffusers. With underfloor air distribution and an air-change effectiveness of 1.10, the same space requires only 150/1.10 = **136 cfm** (75/1.10 = 68 L/s) of outdoor air at the diffusers.

Although 14 percent less outdoor air is needed at UAD diffusers than at overhead VAV diffusers, this savings does not pass entirely to the outdoor air intake. To find out why, see "Effect of Air Distribution on Ventilation Airflow" on page 4. ■

Many UAD systems supply a relatively *constant* volume of airflow to both interior and perimeter zones. According to the fan laws, a 50-percent reduction in external static pressure (typical of UAD) yields the same brake-horsepower effect as a 30-percent reduction in airflow. VAV systems that serve both types of zones often operate for many hours at less than 70-percent of design airflow. Which system actually uses less fan energy? Learning the answer requires a careful, case-by-case analysis of part-load operation.

Improved chiller efficiency. In arid climates, 65°F DB (18°C) supply air *may* be dry enough during most hours of operation to avoid elevating the relative humidity in the space. If so, then raising the chilled water temperature from 45°F (7°C) to 55°F (13°C), for example, will improve the chiller's Coefficient of Performance or COP. For most climates, however, saturated 65°F DB (18°C) supply air would unacceptably raise the relative humidity in the space. Therefore, when a cold coil provides dehumidification, the chilled water in most climates must be cold enough to produce a supply-air dew point of 58°F to 60°F (14°C to 15°C), greatly reducing the anticipated COP improvement.

In other words, the warmer supply air temperatures of UAD systems can improve the operating efficiency of chillers applied in *dry* climates. However, this advantage diminishes significantly in climates that routinely require mixed-air dehumidification (that is, cold water temperatures) at the cooling coil.

Note: Using a separate unit for dehumidification (an active desiccant dehumidifier, for example) allows the chilled water temperature to rise along with the chiller COP… but perhaps at the expense of overall system efficiency. Again, careful analysis is needed to assess the effects of such a design.

Reduced electrical demand. In UAD applications, the floor slab forms part of the supply duct for one floor and part of the return duct for the floor below. Therefore, the thermal mass of the floor slab can store heat (cooling load) during daytime hours and release it at night; see "Thermal Storage" on page 6.

With proper controls and sufficient slab mass, lower daytime cooling peaks may permit smaller cooling equipment and—when coupled with fan-horsepower savings—may reduce daytime electrical demand peaks and charges. Unfortunately, without dependable models to predict the slab's thermal performance or a wealth of design experience, it is unlikely that designers will risk reducing the installed capacity of the cooling plant.

More hours of economizer cooling. When outdoor air enthalpy is less than return air enthalpy, less energy is required to mechanically cool outdoor air than mixed air. Return air is warmer in UAD systems than in VAV systems—perhaps 80°F (27°C) versus 77°F (25°C) at economizer conditions. Therefore, the changeover from "mechanical cooling with minimum outdoor air" to "mechanical cooling with maximum outdoor air" occurs at warmer outdoor conditions, reducing the cooling coil load and increasing economizer hours slightly during warm weather.

UAD systems also supply warmer air than VAV systems—perhaps 65°F (18°C) versus 55°F (13°C). So, the changeover from "mechanical cooling with maximum outdoor air" to "modulated economizer cooling" occurs at a warmer outdoor temperature, reducing the hours of mechanical cooling operation during cool weather.

Airflow

Vertical distribution of the cooling loads within the occupied space determines whether the required airflow for UAD systems is more or less than for overhead VAV distribution. Lacking better load-modeling tools, most designers assume that both types of systems require the same supply airflow at the design cooling condition. In effect, they're assuming that only 50 percent of the cooling load enters the "breathing zone." Therefore, a 50-percent reduction of the supply-to-space temperature difference (typically from 20°F to 10°F) can be tolerated without changing the supply airflow.

After researchers establish comfortable stratification limits and devise tools to aid air-distribution design, some UAD systems may actually be found to require less supply airflow than overhead alternatives. ■

Finally, because UAD systems usually deliver roughly constant airflow to interior spaces, the change from "modulated economizer cooling" to "heating with minimum outdoor air" may occur at a warmer or cooler outdoor temperature (depending on the building cooling load) than in VAV systems. In other words, heating hours may either increase or decrease during cold weather. Why? Interior zones usually do not require heating during occupied hours. Therefore, while "heating with minimum outdoor air," the heating coil warms the mixed air to the current cooling setpoint.

Because UAD systems usually require warmer supply air, they may actually use more heating energy for interior spaces than VAV systems…even if the hours of heating operation decrease.

Stated simply, a UAD system can decrease the cooling coil load during warm weather *and* decrease the hours of mechanical cooling operation during cool weather (especially in dry climates). During cold weather, however, underfloor air distribution may *increase* heating energy use and/or hours of heating operation, depending on building loads.

Ultimately, local weather and load conditions, together with system control schemes, will determine how much extra mechanical cooling energy UAD saves and how much extra (if any) heating energy it adds. Once again, careful analysis is needed on a job-by-job basis to quantify the operating cost savings.

Economizer Considerations

It's important to remember that economizer cooling removes only the *sensible* cooling load in the space. In "non-dry" (most) climates, the latent load must be removed, too…even when the outdoor air temperature drops below the supply-air target.

If system controls sense and directly limit relative humidity in the occupied space, then underfloor air distribution requires approximately the same cooling capacity as overhead VAV distribution. Furthermore, UAD may also require more reheat energy to avoid overcooling during dehumidification.

One final caveat: If your system design uses a return-air bypass configuration to provide indirect dehumidification without sensing (and limiting) relative humidity, then return air will *not* be available for "reheat" during "mechanical cooling with maximum outdoor air." (Dehumidification in constant-volume systems was discussed in a previous *Engineers Newsletter,* volume 29–4. You can find it in our online archive of newsletters in the commercial section of www.trane.com.) ■

Thermal Storage

Although sometimes described as a potential "cool-storage device," "heat-storage device" may be a more apt descriptor for the floor slab. That's because the average temperature of the slab rises during the day as it absorbs and stores heat from internal cooling loads.

Operating a UAD system at night cools the slab by allowing it to reject the stored heat. This practice requires careful consideration, however. Cooling the slab below the "occupied" temperature may necessitate morning warm-up, which can be difficult from under the floor; it can also greatly diminish thermal storage benefits. Furthermore, if the slab mass reaches thermal equilibrium while the space is occupied (that is, if the slab stops absorbing heat at 2 p.m., for example), then the cooling load shift is not sufficient to allow a reduction of the installed capacity of the cooling plant. ■

Growing Pains

Naturally, the relative newness of underfloor air distribution presents certain difficulties for owners and designers who wish to apply it successfully.

Design tools. Neither the guidelines for traditional air-distribution systems nor existing computer-aided design tools address partially stratified spaces. What's missing?

- A good **room–stratification model** to analyze the effects of supply airflow, temperature, diffuser performance, and ceiling height
- A good **load-prediction tool** to study the vertical distribution of cooling and heating loads within the space and to determine the required supply airflow
- A **system–performance model** (one that includes various plenum configurations, slab dynamics, and flexible control schemes) to analyze and compare system economics

Perimeter spaces. UAD systems can readily accommodate thermally stable interior spaces, but spaces with widely variable loads (conference rooms and perimeter spaces, for example) pose a significant design challenge. Solutions ranging from series fan-powered VAV to changeover-bypass VAV to variable-speed fan–coils have been used with varying degrees of success. The "best" solution may be something else altogether and, in any case, will depend upon architectural considerations (for example, window/wall construction and access to vertical riser shafts).

Central systems. Should each floor have one or more air handlers, or should a central air handler provide conditioned air to a shaft with "takeoff" dampers on each floor? Perhaps the central air handler should provide 100-percent outdoor air to fan-powered mixing boxes on each floor. If so, should the central unit merely cool the air, or should it also dehumidify the air to mitigate the interior latent load? These questions may be easy to answer for some applications and impossible for others. One thing is certain: Evaluating the alternatives requires good performance models.

Controls. Minimizing temperature swings at "head" level while controlling "nose-to-toes" temperature stratification is critical for thermal comfort. The ability to model a stratified space would let designers compare the effects of constant- versus variable-temperature supply air, constant versus variable supply airflow, neutral versus pressurized plenums, and so on.

Economizer changeover control and supply-air-temperature reset must be coordinated to maximize economizer hours without causing high levels of relative humidity in the space or requiring excessive reheat. The thermal mass in UAD applications may significantly alter the characteristics and requirements for night setback and morning warm-up operation. Operable windows, which are increasingly popular, create another design perplexity: defining a control strategy that effectively accommodates hybrid (mechanical plus passive) ventilation systems. Control challenges abound.

Installed cost. Does a building with a UAD system cost more or less than a building with a conventional air distribution system? Although most designers believe that buildings with UAD systems demand a first-cost premium, study results to date are inconclusive. Obtaining true cost comparisons is difficult because many designers, installers, and operators raise their estimates to cover unforeseen contingencies associated with the unfamiliar UAD technology.

Will operating cost savings, including the cost of "churn," provide rapid payback for any initial premium? A fair comparison of life-cycle costs requires an economic analysis tool that accurately models both UAD and conventional HVAC systems and their controls.

Retrofit limitations. Existing buildings account for more than half of HVAC equipment sales. Although possible, it's not easy to install an access floor and UAD system in an existing building.

Other uncertainties…

- Standards and codes assume well-mixed spaces and ceiling plenums. UAD shifts the traditional system paradigm for code authorities as well as for designers. Aspects of underfloor air distribution may conflict with existing code requirements.
- Except for passive floor-mounted diffusers, manufacturers offer only a limited selection of UAD equipment and systems.
- Will spilled coffee and dirt in the floor plenum affect indoor air quality?
- Will the occupants of buildings with access floors and UAD systems remain satisfied after five or ten years of operation?

Time and attention may eventually resolve these "growing pains," and perhaps significantly alter our existing paradigms for air distribution. Once these "growing pains" are understood—and after designs for UAD systems are proven, implemented, commissioned, and properly operated—we may find that UAD systems are a viable and practical alternative for specific applications. We may also find that many UAD "advantages" result in real benefits for building owners and occupants.

UAD Research Initiatives

At the University of California in Berkeley, the **Center for the Built Environment** (CBE) conducts research related to underfloor air distribution for industry partners and several government departments, as well as for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). With ASHRAE sponsorship, the CBE is also developing the *ASHRAE Design Guide for Task/Ambient Conditioning and Underfloor Air Distribution Systems* (1064-RP). For more details about UAD technology and the CBE's research programs, visit www.cbe.berkeley.edu/underfloorair/.

ASHRAE and the Air-Conditioning and Refrigeration Technology Institute (ARTI) also sponsor UAD research by **Carnegie-Mellon University** in Pittsburgh. The university's ongoing demonstration project serves as a test-bed for adaptations of underfloor air distribution. ■

Closing Thoughts

Should you raise the floor merely to accommodate underfloor air distribution?

Probably not. It is seldom economical to spend many first-cost dollars on an access floor to save only a few first-cost or operating-cost dollars on the air distribution system.

Why use underfloor rather than overhead air distribution in an office?

- If the plan includes an access floor to reduce the cost of churn, UAD systems can help subsidize the cost added by the flooring. They typically require less ductwork and certainly less "above-ceiling" height than overhead systems. This trait often avoids the increase in slab-to-slab height that might otherwise result from raising the floor.

- In some climates, UAD systems may significantly reduce operating costs.
- Occupant-controlled airflow seems to improve both comfort and productivity.
- Architectural constraints imposed by some building designs may necessitate underfloor air distribution.

What lies ahead? With the help of university researchers, the HVAC industry is expanding its knowledge of underfloor air distribution through studies and through operating experience in both demonstration projects and actual buildings. (See "UAD Research Initiatives" on page 7.)

From these initiatives, we can expect to resolve many of the uncertainties identified earlier in this article … *and* to benefit from the development of design guidelines and tools that will help us use underfloor air distribution to best advantage. ■

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