3 Underfloor Air Distribution

Introduction

The Medical Office Building makes use of a raised floor system as an electrical and telecommunications plenum. It does not utilize this space as a mechanical plenum, instead sticking with a traditional overhead ventilation system to provide air for the space. Because the raised floor already exists in the building, it makes sense to maximize the use of this space by introducing an underfloor air distribution (UFAD) system.

Solution Overview

There are several varieties of underfloor air distribution systems. The system most adaptable to an existing raised floor would be a fully ducted system. However, this does not generate any savings compared to an overhead system, as just as many ducts, if not more, would be required. A better alternative is a pressurized plenum. Although this system may require a different raised floor to prevent leaks, it would not interfere with the current use of the plenum. Therefore the UFAD system redesign will be a pressurized plenum system.

Design Criteria

The purpose of heating ventilating and air conditioning (HVAC) systems is to provide for human health and comfort in buildings. For this reason the system should be judged on:

- The ability to provide a thermally comfortable environment
- The ability to provide enough air for a healthy environment

If the system can meet both of these requirements then it should be termed an acceptable alternative. The issue of cost is also important, but since the raised floor is already present in the building and there will be less ducts with a pressurized system, cost savings are already assumed.

Environmental Comfort

The design of UFAD systems takes into account the same loads as conventional HVAC systems. However, because UFAD systems rely on convection from heat sources in an occupied zone, the thermal load they are expected to remove is calculated only to a height of 6 ft. Any heating load that acts only in the unoccupied zone does not have to be taken into account when determining the amount of ventilation required for thermal comfort.

For the purposes of this investigation, an area of open office space (Figure 3-1) was chosen as a basis for the system design. For the sake of simplicity, it was assumed that the surrounding interior

environments are kept at the same temperature as the open office, and therefore have a negligible effect on the loads in the space. The exterior window still effects the loads in the Medical Office Building through conduction from and infiltration of the outside air. A full list of the loads and their contribution to each of the zones is summarized in Table 3-1.

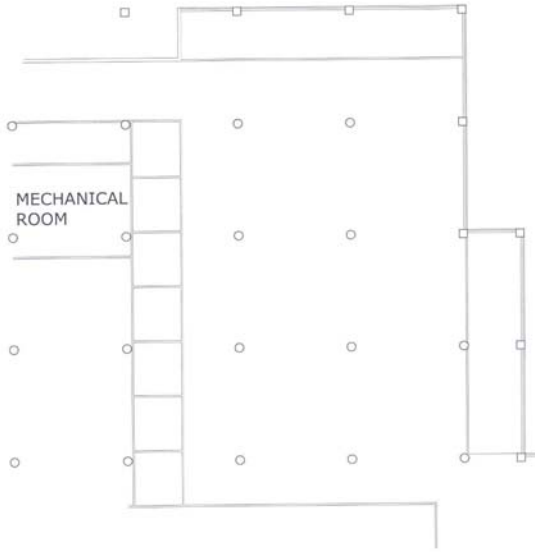

Figure 3-1 Plan of area for proposed UFAD system

Source	Unoccupied Load (Btu/hr)		Occupied Load (Btu/hr)	
	Winter	Summer	Winter	Summer
Lighting	7400	7400	29600	29600
Occupants	0	0	10800	10800
Computers	0	0	13226	13226
Infiltration	-586	199	-4102	1390
Conduction	-2213	750	-6935	2349
TOTAL	4601	8349	42589	57365

Table 3-1 Summary of loads in both the occupied and unoccupied zones

The amount of air required to remove heat from a space can be determined from:

$$q = 1.08\dot{V}\left(T_{\text{sup }ply} - T_{exhaust}\right) \qquad (3\text{-}1)$$

For typical UFAD systems, air is supplied at 65°F. On average, most people are comfortable in an environment that is 72°F, this condition will be assured if the exhaust temperature is at this temperature. Based on thermal comfort, the required ventilation for the space is 7588 cfm. However, thermal comfort alone does not make an adequate ventilation system. Human health is also an important requirement. ASHRAE Standard 62 sets a requirement that outdoor air be provided to maintain a healthy environment. For this office space, the required ventilation for human comfort is 585 cfm.

System Layout

Knowing the required ventilation for the office space, it is possible to layout a system of diffusers. There are several diffusers available on the market for UFAD systems. However, most of these systems require an 8" raised floor. The current raised floor in the Medical Office Building is only 6", therefore it is necessary to raise the floor another 2" to accommodate the diffusers. Typically, this would be problematic, as higher ceilings are beneficial to UFAD systems. Fortunately, the use of two-way flat slabs can be used to provide an additional 9" of usable space. With the floor now at an appropriate height, a Trox swirl diffuser (Appendix IV) that can provide 110 cfm was chosen for the system. Assuming that these diffusers would operate at 100 cfm, it would be necessary to place 76 diffusers.

For the sake of even spacing in the floor grid 77 diffusers were distributed across the open office area. Because the chosen UFAD system operates based on a pressurized plenum, it is important that each diffuser have an equal pressure differential. Research has shown that the best way to ensure an even pressure differential is to limit the distance from the duct outlet to any diffuser to 80' or less in an 8" plenum[1]. The dimensions of the open office area are small enough that a duct feeding the center of the space could meet this design requirement. A schematic of the final system showing the duct position and the diffusers appears in Figure 3-2.

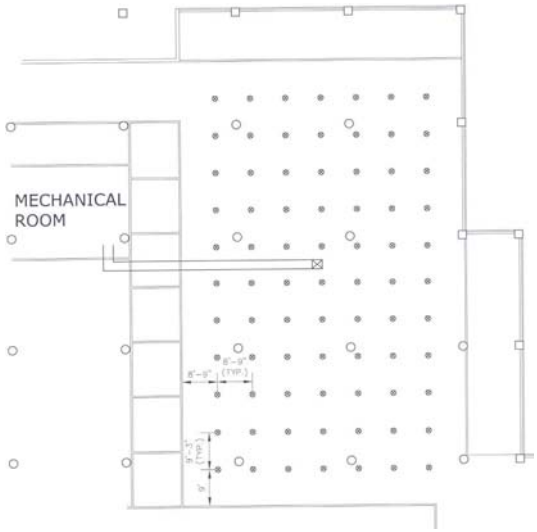

Figure 3-2 Layout of the final UFAD system for the open office area

Conclusions

The UFAD system provides an adequate level of thermal comfort and meets the standards for providing fresh air to the space. Based on the amount of ventilation for air quality compared to the amount required for thermal comfort, it would seem possible to recirculate as much as 94% of the indoor air. However, because of the stratification caused in rooms with UFAD the air in the unoccupied zone is not nearly as adequately ventilated as the air in the occupied zone. Even so, it

would still be reasonable to introduce some level of recirculation to the UFAD system. This, along with the energy savings related to supplying air at 65°F instead of 55°F, make the UFAD air distribution a very good alternative to an overhead air system.

Unfortunately, simply applying a UFAD system indiscriminately could be disastrous. The design for this system took advantage of the higher ceiling created by switching to a two-way slab system. If the Filigree system were still in use, the floor to ceiling height would leave only 2'-6" in the unoccupied zone, instead of the 4'-6" in the new system. This would likely result in more circulation of contaminated air from the unoccupied zone into the occupied zone. Therefore, it is important that the UFAD system only be applied if the two-way slab system is introduced.

[1] Bauman, Fred S. Underfloor Air Distribution (UFAD) Design Guide. ASHRAE. Atlanta, GA. 2003