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Exterior of Hamilton Landing project, which is a retrofit of a 70-year-old Air Force base hangar.

Underfloor Air System for Retrofit Office Complex

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When the HVAC design of the Hamilton Landing project was first conceived in 1998, it consisted of large package air-cooled rooftop units sitting next to the historic hangars with a conventional overhead VAV reheat system.

The developer, however, liked the underfloor presentation made for the project and asked the architect to incorporate the concept. Along with the usual benefits of underfloor air, this project had features that made it even more suitable for a raised floor.

The ground floor slabs of the 70 year-old Hamilton Air Force Base aircraft hangars had settled into the Bay mud, bowing down from the edges to the center of each hangar.

The proposed solution to this was to pour a topping slab to level the ground floor, which was budgeted at $3/ft^2 ($32.29/m^2). Each of the seven 30,000 ft^2 (2787 m^2) hangars was also planned to accommodate a second floor, supported from the ground floor slab, increasing the gross square footage of each hangar to about 58,000 ft^2 (5388 m^2). Footings for the second floor columns would have

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had to be poured below the existing slab, requiring cutting of the slab at 30 ft (9 m) centers. The raised floor eliminated this cost. The floor covered a multitude of sins, which helped pay for itself.

Given the character of the 45 ft (14 m) high vaulted ceilings of the aircraft hangars, suspended ceilings were not a desired interior treatment, which meant that any ductwork would be exposed and mounted high up at the structure. This would have posed a challenge in several respects.

Heating would not be done very efficiently, and ventilation air would be difficult to throw into each cubicle. Any enclosed spaces, such as conference rooms, would require duct drops that would be tricky to support and aesthetically difficult to design. Given that zoning flexibility is needed, variable-air-volume (VAV) reheat is required, which is much more difficult to design exposed with a clean appearance compared to constant volume (CV) single zone ducts.

The cost of making exposed ductwork acceptable in appearance was avoided by the use of the raised floor. A similar problem would have been present for the power and communications cabling, with exposed raceways and power poles.

Right across a narrow street from the hangars is a development of new homes. Having large air-cooled units sitting next to the hangars would have been unsightly and noisy. Locating all the mechanical equipment, such as water-cooled direct expansion (DX) units, boiler and cooling tower inside the building, enabled the appearance of the historic buildings to be preserved, site landscaping to flourish and noise to be controlled. Locating HVAC units on the lightly loaded, barrel-vaulted roof was not an option from structural, aesthetic and maintenance perspectives.

It is often difficult to accurately compare the cost of systems at a conceptual level, and this is especially true when the alternate being considered is relatively new. Even if historical data is available, unfamiliarity can bump up the estimator's numbers. In this case, the developer had a budget of about $\$85/ft^2$ ($\$915/m^2$), which included a seismic upgrade of the building, new curtain wall and windows, new roof and all new base-building systems with the shell and core. The HVAC budget was $\$8.50/ft^2$ ($\$91.50/m^2$) and the cost of the raised floor about $\$7/ft^2$ ($\$75.35/m^2$). This worked with the previous factors to stay on the budget planned earlier, but required some faith in the raised floor system pricing.

Architectural Improvements

Architecturally, the adaptive reuse was designed to disturb as little of the existing façade as possible to maintain the historical integrity of the hangars. Each hanger has a large, rectangular floor plate measuring 240 ft by 120 ft (73 m by 37 m). Attached to each corner of the building is a 12 ft by 12 ft (3.7 m by 3.7 m) tower that rises 38 ft (11.6 m) above grade. These concrete towers with 11 ft by 11 ft (3.4 m by 3.4 m) clear inside were used for housing four water-cooled DX VAV air-conditioning units on the first floor, and a boiler and cooling tower on the second floor.

Conference room in the interior of an office at Hamilton Landing.

The building envelope is comprised concrete walls and a builtup roof with an overall insulation level of R-19. The glazing is a reflective single-pane glass with a U-value of 0.95 and a solar heat gain coefficient (SHGC) of 0.37. The facility has an overall glazing ratio of approximately 40%, with both the north and south elevations having over 58% glazing.

HVAC System Overview

Four 30-ton (106 kW), water-cooled air-conditioning units, each sized to provide 15,000 cfm (7079 L/s) of supply air, serve both floors of each quadrant of the former hangars. These units receive condenser water from a single 200-ton (703 kW) forced-draft cooling tower, which provides 80°F (27°C) water, circulated by a 7.5 hp (5.6 kW) pump. A boiler provides heating hot water for the perimeter hydronic reheat zones. Hot water is distributed in a variable-flow pumping scheme with reverse return and a 2 hp (1.5 kW) hot water pump with variable speed drive.

Access flooring using pedestals 18 in. (0.5 m) above the ground floor slab and 12 in. (0.3 m) above the second floor slab were used as supply air plenums. This space also is used for cable distribution (electric/phone/data) throughout the space.

Individually adjustable, floor mounted supply air diffusers regulate the airflow being supplied to the spaces. These diffusers provide the occupants with control over the airflow to their space.

The air-conditioning units were designed to maintain indoor temperatures between 70°F and 78°F (21°C and 25°C) and they supply air to the underfloor plenums at elevated temperatures of 63°F (17°C). At the perimeter of each floor, linear floor grilles with hot water linear convectors heat the supply air as required. The perimeter zones are provided with pressure dependent volume dampers located in the plenum dividers. This eliminated the need for fan-powered boxes.

The mechanical system was designed to fit within the existing corner towers at each hangar. Each air-conditioning unit occupies the first floor of a single tower, and is a tight fit. The second floor of the northeast tower contains the boiler while the second level of the southeast tower houses the cooling tower, also a tight fit, and its associated pumps.

The first level of each tower has louvers for outdoor-air intake and serves as an intake air plenum for the air conditioner. Second floor louvers provide intake air for the forced-draft cooling tower, which discharges through the roof, and for toilet exhaust.

The mechanical equipment is, therefore, entirely integrated into the original building design, being very unobtrusive. Return air is transferred through sidewall openings from the towers to the interior space on each level.

Energy Efficiency

The building design is 29.6% below the 1998 California Title-24 Energy Standards, and the facility qualified for more than $55,000 in owner utility incentives. The project site weather climate has summer conditions (ASHRAE 0.5%) of 87°F (31°C) DB and 63°F (17°C) WB and winter conditions (ASHRAE 0.2%) of 30°F (–1°C) DB. The typically mild conditions allow the facility to use many hours of "free cooling" through the use of an airside economizer. The low wet-bulb temperature ensures that water cooled equipment can be efficiently applied.

The use of an underfloor system meant that many more economizer hours were possible with a 63°F to 65 °F (17°C to 18°C) supply air temperature compared to a typical system with 55°F

Interior photograph of the Hamilton Landing project.

(13°C) supply air temperature. Utilizing water-cooled equipment allowed the nominal cooling efficiency to be increased from about 1.1 kW/ton (0.3 kW/kW) for air-cooled equipment, to 0.7 kW/ton (0.2 kW/kW).

The underfloor air distribution system results in low external static pressures (0.05 to 0.08 in. w.c. [12.5 to 20 Pa]) reducing the amount of fan power consumed. Variable frequency drives (VFDs) were installed on all the supply fans. The VFDs are used to maintain a constant static pressure in the supply plenum as the tenants open and close individual diffusers, or VAV zones modulate. Motorized dampers were provided behind the existing building louvers, which are now used for relieving air from the space when the units are in economizer mode, thus avoiding the energy use of return or relief fans. The underfloor air system supplying air at a temperature closer to that of room temperature results in less concern about operable windows conflicting with air conditioning. All fans and pumps were specified with premium efficiency motors.

Conclusion

Many different types of tenant improvements have been successfully accommodated at Hamilton Landing, including a YMCA, branch library, full service kitchen and deli, as well as a multitude of office uses.

This project demonstrates that underfloor air can be a cost-effective solution for retrofits and speculative office buildings. The flexibility, comfort, indoor air quality, and energy efficiency of underfloor air are very affordable, if not lower cost than conventional overhead systems when executed well.

Underfloor air has been growing in its acceptance in the United States and many new products, including fan-powered VAV reheat boxes, and floor diffusers are now available. Design guides, such as the *Underfloor Air Distribution (UFAD) Design Guide* published by ASHRAE, have been written, and more data is available now for cost comparisons, and technical considerations such as leakage, which will help designers and decision makers.