1998
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This project won in the category for Residential

Three-level student apartments in Greensboro, N.C., use energy recovery ventilation systems to save energy.

Total Systems Design

By Harry John Boody
Member ASHRAE

A "Total Systems Design Approach" was used to design a new three-level student-housing apartment building in Greensboro, N.C. The structure consists of 12 apartments (four students in each apartment) with 12,936 ft² (1202 m²) of gross floor area.

A total systems design approach is achieved through the interrelationship of the structure's component parts and by matching the source to the load. This systematic approach produces a safe and healthy living area that offers the occupants durability, comfort and energy efficiency. The "maximum power transfer" theorem states: If one matches the design source (HVAC System) to the design load (total thermal envelope and internal loads), maximum energy transfer will be achieved.

The design team implemented a total systems design approach to achieve maximum energy cost effectiveness and improve indoor air quality without sacrificing comfort. The objectives were to predict and minimize the total load by using a detailed load analysis for each component of the structure and considering all forms of heat transfer and infiltration.

Each 4,312 ft² (400 m²) level of the building consists of four 1,078 ft² (100 m²) student apartments with 8 ft (2 m) ceilings. The total conditioned space is 103,488 ft³ (2931 m³) or 12,936 equivalent square feet (ESF).

Insulation materials were carefully installed per manufacturer specifications and an aluminized vapor barrier was installed over all insulation. The next step involved matching (as close as possible) the load to a heating/cooling source with an acceptable cost/benefit ratio. A system performance analysis was conducted incorporating all available fuel types.

The heat pump was determind to offer the best match source to load. For the first year of occupancy, the HVAC energy consumption to heat and cool the 12,936 ft² (1202 m²) structure to 72°F (22°C) in the winter and 75°F (24°C) in the summer was 39,888 kWh, yielding an average

About the Authors

Harry John Boody is president of Energy Innovations by Harry Boody in Jamestown, N.C. He won two ASHRAE Technology Awards in 1997.

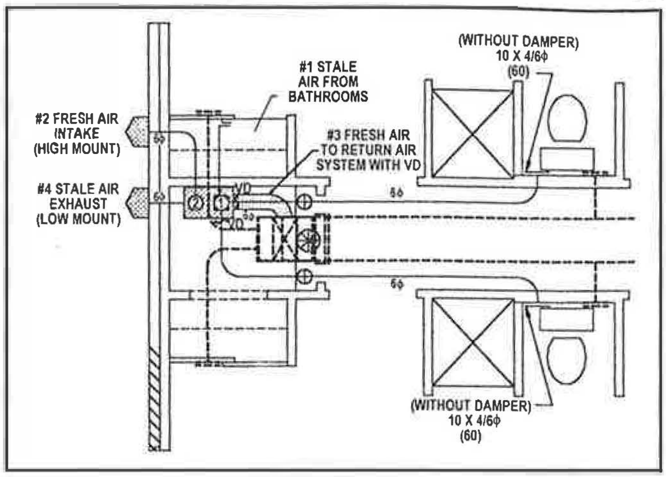

Figure 1: Schematic of energy recovery ventilation system.

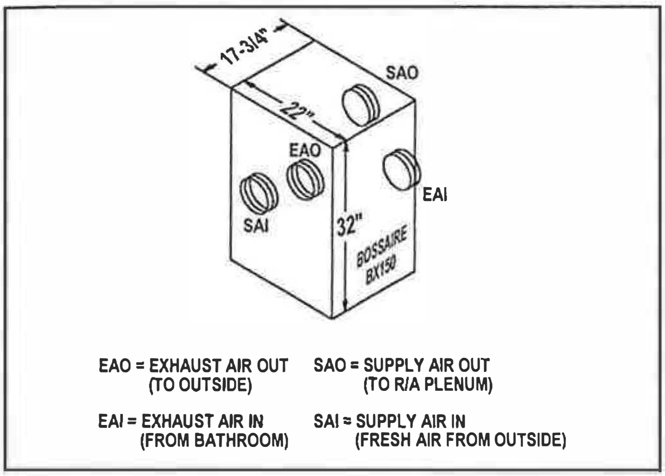

Figure 2: Detail of energy recovery ventilator.

monthly cost of $232 (3,324 kWh ~ $0.07/kWh) or $19 for every apartment each month.

As buildings become more thermally efficient, HVAC equipment manufacturers must design and manufacture smaller capacity equipment to meet the maximum power transfer theorem.

Each apartment is conditioned with a low maintenance 1.5 ton (5 kW) heat pump and a low-velocity duct system. The returns are designed to filter all airflow under 300 fpm (1.5 m/s) across the filter media. More airborne contaminants are removed by slowing down the air velocity (by increasing filter size).

The mode of operation is simple. Thermostats are set at 72°F (22°C) heating and 75°F (24°C) cooling. Each heat pump is equipped with one 5 kW strip heater controlled through the second stage indoor thermostat and an outdoor thermostat set at 15°F (–9.4°C). Therefore, no strip heat is supplied until the outdoor temperature falls below 15°F (–9.4°C).

Energy Recovery Systems

Since the building envelope is tightly constructed, energy recovery ventilation (ERV) systems with an 85% effectiveness, were used in each apartment. Student housing offers a variety of residents and lifestyles (i.e. smokers, non-smokers, different perfumes, odors, etc.) and experiences a greater frequency of visitors than an average household. ERVs should be considered essential in such an environment to help maintain indoor air quality.

One of the innovative features of the design was the replacement of all of the bathroom fans with energy recovery exhaust air returns. From each bathroom in an apartment, exhaust vents feed into one air-to-air energy recovery ventilator for the apartment (a total of 12 ERVs for the building) without affecting proper air distribution.

Pre-filtered outdoor air is drawn into the ERVs' energy core while the stale indoor air is being exhausted across the energy core, thereby exchanging energy between the outgoing air and the incoming fresh air, which is then fed directly into the air handler main return. This fresh air is further conditioned and distributed throughout the apartment through the main air distribution system.

Replacing the filter is the only maintenance required of an energy recovery ventilation system. (An HVAC maintenance person keeps to a regimented preventative maintenance schedule.)

All lighting for this building is low wattage (15 watts) decorative high-luminance fluorescent lighting. Low power 2.7 watts exit lights were specified compared to 40 watts with conventional exit lights. The exit lighting requires no maintenance and saves 326 kWh annually.

Project Costs

This project was cost effective. The additional cost to implement the environmentally sensitive, energy efficient features was $21,720 or $1,810 per student apartment. This cost was included in the 8.5% interest rate mortgage, thus increasing the mortgage payment by $213 each month.

The first year monthly average energy and interest tax savings were $223. (Note: Monthly energy savings are greater than the monthly amortized cost.) By using high efficiency heat pumps with a SEER rating of 13.0, this project qualified for $2,700 in Duke Power Company rebates.

This project yielded immediate positive cash flow savings and has a projected end of 15-year mortgage tax-free return on an investment of 10.3%. Investing in cost-effective energy savings concepts with improved indoor air quality and comfort makes good economic sense.

Acknowledgments

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