DESIGN OF A HEALTHY MODERN OFFICE BUILDING

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Today, more than ever before, the designers of a modern office building need to consider an array of architectural and engineering features. In designing our own building, we have incorporated many innovative concepts. The features presented in this paper have been limited to those expected to facilitate an office environment that is architecturally pleasing, programmatically sound, comfortable, healthy and energy efficient. These features were incorporated into the design of our building without prohibitive costs or design delays. Many of the features incorporated in this design are innovative and once their fruition has been demonstrated in our own building, would be expected to be incorporated in future designs for clients.

INTRODUCTION

In 1988, Harriman Associates (a full-service Architectural and Engineering Firm of 80 people) embarked on the design of its own new 2322 sq. meters (25,000 sq. ft.) office facility. The building is located in a new business park in Auburn, Maine, U.S.A. The undeveloped 8094 sq. meters (20 acre) site is located on the outskirts of the city and is bordered by the Maine Turnpike, a major trucking route, and the local airport. The design goals for this office building incorporated items of both traditional and recent concern. These goals included: building design appropriate to the site, reasonable costs, (less than $1,075. U.S. per sq. meter ($100. U.S. per sq. ft.)), suitability of the facility for its planned usage, superior indoor air quality and comfort, low noise transmission, non-glare lighting, and maximum energy efficiency (less than $22,000. annual energy cost). These goals have been accomplished through the use of many modern concepts that are both proven and unproven. An innovative array of architectural and engineering features were considered and many were incorporated. This paper covers the features related to indoor air quality, health, and the comfort aspects of the design approach.

ARCHITECTURAL DESIGN CRITERIA AND FEATURES

It is not coincidental that Harriman Associates' dedication to design excellence and the decision to build a new office to house and foster this commitment resulted in an environment that stimulates creativity.

Our new office is a three level, two floor structure with a mezzanine designed to expand to meet future growth.

The main floor is organized into administrative and conference areas that are separated from the professional design studios by a sky-lit gallery that is used to display current projects and art exhibits. The studios are large, high-bay open areas that are naturally-lit, whose partitioned work stations can be reconfigured.

The work station dividers are finished sheet rock (gypsum) as opposed to conventional office partitioning. This design was selected for several reasons. In addition to meeting program goals and minimizing costs, eliminating conventional office divider partitions was also expected to eliminate reported long term off gassing of volatile organic compounds from fabric finishes and internal sound absorbing materials.

The design goals for the main floor area included a desire to configure all of the lighting, (natural and high frequency fluorescent), in a manner such that Video Display Terminals (VDT's) could be utilized at any work station without glare or shadowing. In order to meet this goal in areas that were not high bay, high efficiency lighting fixtures specially designed and marketed for use with VDT's were installed.

The firm's principals have enclosed offices located at the corners of the studios, near the people they manage. Architectural and engineering studios are separated by a central volume that contains support services, including a CADD studio, (equipped with a supplemental cooling system and a separate area for plotting), and a central area for staff to meet and share ideas. Staff interaction is further enhanced by team meeting areas located in the center of each studio.

The building's lower level houses printing services, a sample room, employee exercise and locker rooms, a lunch room, a storage vault, and mechanical spaces. Large storage tanks for off-peak energy storage are located in an unfinished area.

The exterior of the building is both sympathetic to its surroundings and playful in its architectural appearance.

ENGINEERING DESIGN CRITERIA AND FEATURES

In 1988, Harriman Associates implemented a company-wide decision to attempt to design all buildings capable of meeting or exceeding the then proposed ASHRAE STD. 62-1981R "Ventilation For Acceptable Air Quality" prescriptive guidelines within normal cost constraints. (1) ASHRAE In addition to our goals of superior air quality, comfort and affordable cost, this building was selected for participation in a Model Energy Efficiency program by the local utility. (2) CMP

In accordance with the principles expressed in the ASHRAE guidelines, State of Maine energy guidelines, CMP model energy efficiency program goals and the goals expressed above, and after much analysis, the following features were chosen to be incorporated in the design of the building:

1. The use of source control as a means of reducing indoor pollutant source terms including: interior finish materials with high volatility solvents for rapid off-gassing, low emission building furnishings, and provisions for local exhaust of all significant identifiable planned internal sources. Smoking is not allowed anywhere in the building.

2. A sub-slab and sub-membrane passive radon gas venting system.

3. The use of secondary transfer air as make-up air, in all non-critical exhausted areas.

4. High ventilation efficiency (a goal of 150+% ventilation efficiency in major portions of the building by ASHRAE definition, utilizing low aspiration high-bay supply and low [kick-board and floor] return).

5. The use of high efficiency air filtration (95% + pleated filters and 30/30 pleated pre-filters) for all of the air supplied to the building.

6. Building positive (+) pressure control, with a system reset feature if too many operable windows are opened.

7. DDC HVAC control with VAV and minimum stops on all boxes.

8. An all-electric building with "off peak" heating and cooling.

9. An energy management system, including occupancy sensors for individual office lighting, peak load shedding capability, and control of off peak energy storage cycles.

10. An energy efficient (R 34 Roof, R 32 Walls) and "tight" building shell design, equipped with argon filled low E glazing, and five percent (5%) of the glazed area operable.

11. A non-glare lighting design suitable for VDT use throughout the building, utilizing high efficiency lighting fixtures, direct and indirect lighting, and high frequency energy efficient electronic ballasts.

12. Individual heating controls on all exterior office areas and individual cooling controls in all enclosed office or conference rooms.

13. Ventilation rates that meet or exceed the ASHRAE guidelines of 20 cfm outside air per person.

Other features considered and evaluated in the design process, but not chosen for incorporation into the initial design included:

a) Central exhaust with full heat recovery ventilation.
b) Partial exhaust heat recovery for latent and sensible energy.
c) Building humidification.
d) A co-generation energy source.
e) On-site fossil fuel based heating and cooling.
f) Automatic dimming lighting control.
g) Active soil gas (radon) venting.
h) Additional daylighting features and automatic controls.
i) Outside air control utilizing Carbon Dioxide or other suitable sensor.

RESULTS AND DISCUSSION

The building was occupied in January, 1990. The location of various departments and the flexibility that the building design offers has facilitated the implementation of a studio concept of operation. This concept allows architects and engineers to come together for a project in one area. This approach has facilitated creative integrated design solutions that can be tailored to a project's unique challenges and then executed in a well coordinated manner.

The total cost of the building is \$ 2.1 million (US) or \$903. per sq. meter (\$85. per sq. ft.) including site work. To date, the building's energy use has performed similar to predictions. Based on preliminary estimates, the projected annual energy costs will need to be increased slightly due to the current base electric load required by the continual operation of computer systems located throughout the building and due to a 7% rate increase. During the coldest periods of the winter, with strong winds and nighttime temperatures of -25 deg. C., the building was able to be both heated and ventilated during the occupied period with the off peak heat that was stored in a water tank. Based on initial temperature observations, nightime shutdown during the coldest weather appears to result in a maximum of 1-2 deg. C. drop in temperature in the building.

A tight schedule dictated that occupancy occur prior to the completion of all interior and exterior finishes and with temporary ventilation and heating control. Scheduling of the application of interior finishes, and manipulation of the economizer and VAV controls of the air handler (such that excessive ventilation was provided in the range of 30 to 50% OA) allowed the staff to occupy the building during this initial time period while construction was completed. Design features include a small percentage of operable windows, an energy efficient building shell, and an on-site trained operator and computer station for the DDC controlled HVAC system, have allowed us to provide periods of excess ventilation during final construction activities (painting). If these features had not been incorporated or the building had been equipped with only minimum ventilation or off-site computer control, the application of the specified interior finishes after occupancy would have most likely caused very unpleasant conditions to occur.

Under normal occupied operation and design conditions, the occupants of the building are expected to be supplied with a minimum of 25 cfm of outside air per person. Under typical economizer operating conditions with temperate weather above 0 deg. C., much greater quantities of outside air will be supplied. Initial continuous monitoring of Carbon Dioxide levels in occupied zones reveals levels which seldom exceed 700 PPM with the highest readings occurring during peak late morning and late afternoon occupancy while operating at design conditions.

Monitoring of the fine particle levels in the building and further monitoring of comfort parameters and energy utilization is planned. The use of a carbon dioxide sensor to control outside air quantites will be re-evaluated. Based on initial testing of design supply rates, the building appears to behave as a well mixed zone, suggesting that one sensor in the return air may be adequate for representative sampling and control.

All of the air entering the print room located in the basement is exhausted out of the building. Initial monitoring of humidity levels in the building have revealed the lowest readings to be in the range of 20 % RH. Humidification during cold weather extremes may be required in the CADD plotting studio in order to minimize the likelihood of equipment problems associated with low humidities.

Original plans called for room pressure control of the unfinished (gravel floor) area that houses the off-peak storage tanks. Changes in the program of the building will limit the ability of the area to remain under pressure control, thus an active sub-membrane depressurizaton system will be installed, if needed, in order to control soil gas infiltration in the unfinished area.

Original specifications of the air handling unit call for ease of maintainability. The stock unit as available from the factory does not appear to provide adequate access for drip pan inspection and cleaning. In order to avoid charges for the delivery of custom equipment, an access door will be added on site.

CONCLUSIONS

Our comprehensive approach to designing for superior air quality and comfort included the basic principles of source control and good HVAC design. Support for energy efficient features of the building allowed these goals to be met while still maintaining a reasonable capital cost and energy budget.

Based on building energy modeling, our initial observations, and testing conducted to date, thorough program planning and HVAC design appears to have resulted in a design with good thermal comfort control throughout the building and systems that can be operated in a manner which will facility superior indoor air quality and energy efficiency.

ACKNOWLEDGEMENTS

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