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DESIGN OF A MODERN SCHOOL: HEALTH, COMFORT, AND ENERGY CONCERNS/ASHRAE STD. 62-1989

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In 1988, Harriman Associates designed the Benton Elementary School so it would include state of the art architectural and engineering features. These features are expected to facilitate an environment that is architecturally pleasing, comfortable, healthy, and very energy efficient. The design features include a small school ambience, heat recovery ventilation (latent and sensible), and radon resistant construction. These features were incorporated into the design of the school without prohibitive cost or design delays. Many of the features incorporated in this design will become necessary in future schools in the northern climate of Maine if the schools are to be capable of meeting mandatory energy, ventilation, and radon guidelines. After occupancy, the modeled performance of the school can be confirmed with testing.

INTRODUCTION

In 1988, Harriman Associates embarked on the design of a 7805 sq. meters, (84,000 sq. ft) elementary school to be located in Benton, Maine, U.S.A. The school was designed for Maine School Administrative District #49, Edward Fabian, Superintendent. The school is currently under construction and scheduled for occupancy in September, 1990.

One of the major architectural design goals chosen by Harriman designers and the school building committee was that the school should provide a small school ambience in a single building for the 800 children that would be attending this regional school. A major engineering design goal chosen for this school was that in addition to meeting the Energy Usage Codes of the State of Maine Bureau of Public Improvements, that it also meet the then proposed prescriptive guidelines of ASHRAE Std. 62-1981R, without causing significantly increased construction or operational costs. (1) ASHRAE This engineering goal was chosen by Harriman and the Owner for health and comfort concerns in anticipation that the then proposed ASHRAE criteria would be incorporated into Maine State law in 1989 or 1990.

As Maine is an area known to have a strong potential for Radon in soil gases, the Owner had expressed an interest in reducing the likelihood that radon gas could be a problem in the new structure.

The remainder of this paper presents and discusses the design approaches utilized to meet both the architectural and engineering criteria chosen for the school.

ARCHITECTURAL DESIGN CRITERIA AND FEATURES

To provide a small school ambiance for 800 children in a single building was the overriding challenge in designing this regional elementary school. The overall approach was to renovate and adapt the original school for music and fine arts activities and to add three classroom wings. The central lobby and resource center are surrounded by naturally-lit corridors that provide for occupant circulation between wings. The result is an innovative environment that simulates the neighborhood school experience in any given wing. (See figure 1)

At the heart of the program are the three classroom wings that each house two grades featuring four varieties of teaching space. Private tutoring space encircles the large activity area at the core of each wing. Demountable walls allow formal classrooms on the perimeter to be expanded quickly into longer, lecture style classrooms.

The exterior's rambling rooflines and partial courtyards, common to many farmhouses in this rural community, reflect local architecture. Stepped color treatment evident at entrances creates images of "The Little Schoolhouse" of earlier times, further reinforcing the small school feeling. (See figure 2)

ENGINEERING DESIGN CRITERIA AND FEATURES

Ventilation, Comfort, and Energy Efficiency

In 1988, Harriman Associates implemented a company wide decision to attempt to design all buildings to meet or exceed the proposed ASHRAE STD. 62-1981R "Ventilation For Acceptable Air Quality" prescriptive guidelines. Thus with the Benton Elementary School, the design team was faced with the challenge of meeting the prescriptive ventilation criteria of supplying both a minimum outside air quantity and of meeting the stringent energy usage guidelines imposed by the State.

The design approaches were chosen with regard to meeting the ventilation guidelines and keeping energy usage at an acceptable level and include the following:

1. The use of full heat recovery (including latent heat/moisture recovery) in all classroom areas.

2. The use of economizer cooling in many areas of the school.

3. The use of Variable Air Volume (VAV) controls with minimum stops in areas of intermittent occupancy.

4. The use of medium efficiency air filtration.

5. The use of transferred secondary air in many non-critical exhausted areas.

These strategies were modeled for energy consumption and are expected to allow the school to meet or exceed the prescriptive ASHRAE Std. 62-1981R guidelines without exceeding the stringent State of Maine Bureau of Public Improvement energy usage budgets. Results of the energy analysis revealed a total projected use of less than $43,250. (US) annual energy cost.

Radon Resistant Construction

The goal of reducing the likelihood of Radon being a problem in the occupied building was addressed by first conducting a pre-construction assessment of the site. Based on limited wintertime measurement of Radon gas of 2035 Bq/meter cubed (55 PCi/L) in an unfrozen pipe trench of the partially demolished original school building, and on the known geology of the area (blasted bedrock), and the known geology of Maine, it was postulated that the infiltration of soil gas into the completed building could cause elevated levels of Radon. Thus, in addition to providing good ventilation for the building during the occupied periods, and providing positive presssure in the classroom areas, the foundation drainage system for the building was expanded into a passive soil gas (radon) venting system. Based on information which was available from the US EPA at the time of design concerning radon mitigation in homes, and verbal discussions with researcher Terry Brennan, a decision was made to add vertical soil gas vents to the foundation drainage system. These were spread throughout the school on the order of one vertical vent for each 930 sq. m. (10,000 sq. ft.) of floor area. The final design equipped the building complex with twelve vertical passive soil venting stacks. In addition, these passive vent stacks could be made active if upon testing during occupancy it was found that additional protection was needed.

The design approach of one vertical stack per 1000 sq. m. or 10,000 sq. ft. of earth contact floor area, and utilization of a porous aggregate, reinforced vapor barrier, and the sealing of all expansion joints and earth openings has recently been proposed by the State of Maine Bureau of Public Improvements, Division of Safety and Environmental Services, as a possible mandatory radon-resistant construction feature in State funded buildings.

RESULTS AND DISCUSSION

To date the construction of the building has proceeded, and it is currently scheduled for occupancy in September, 1990. The total cost of the building is $5.8 million (US) or $743. per sq. meter ($69 per sq. ft.). The addition of the passive radon vents was accomplished with a change order at an additional cost of $10,000. (US). Based on preliminary estimates, the cost to provide the currently proposed State of Maine Mandatory Radon Resistant Construction features is in the range of $ 3.23 (US) per sq. meter ($ 0.30 US per sq.ft.)

Modeling of the Harriman Associates' design approach for the school's ventilation system has allowed the school to meet the state life cycle cost budgets, annual energy usage budget, and recently adopted ASHRAE perscriptive ventilation guidelines without any significant increase in construction cost.

In July of 1989, a year after the completion of the school's design, the State of Maine Bureau of Public Improvements did adopt mandatory requirements for ventilation that require all newly constructed schools to meet the ASHRAE 62-1989 "Ventilation For Acceptable Air Quality" guidelines.

Based on the expected success of the Benton design, the combined approach of heat recovery ventilation, VAV with minimum stops, and economizer cooling has now been implemented on several of our ongoing school designs.

It is anticipated that the State of Maine will also adopt mandatory Radon Resistant Construction Standards for State of Maine funded projects to become effective July of 1990. Because of this and the growing concerns of radon exposures in buildings, we are currently attempting to design passive radon resistant features into our current projects.

The performance of the ventilation approach and radon resistant construction features that have been designed into the Benton Elementary School, will hopefully be confirmed with testing during the first season of occupancy during the fall of 1990 and spring of 1991.

CONCLUSIONS

An integrated approach of ventilation and heating design which incorporates source control of pollutants, heat recovery ventilation (latent and sensible), and energy efficient design strategies, has been utilized in the design of this modern school. This design approach is expected to result in a school environment that will meet or exceed all proposed or existing guidelines for good indoor air quality.

ACKNOWLEDGEMENTS

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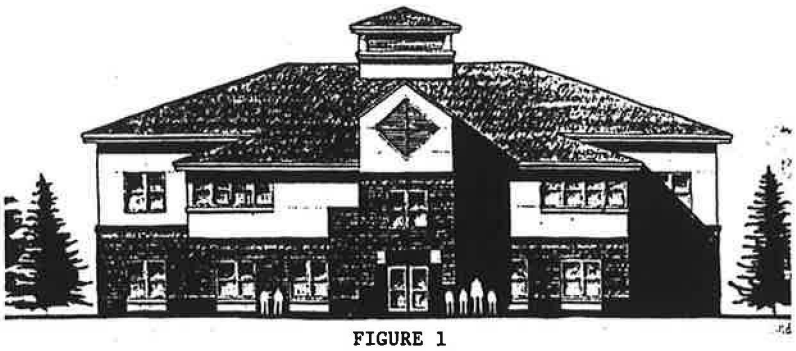

FIGURE 1

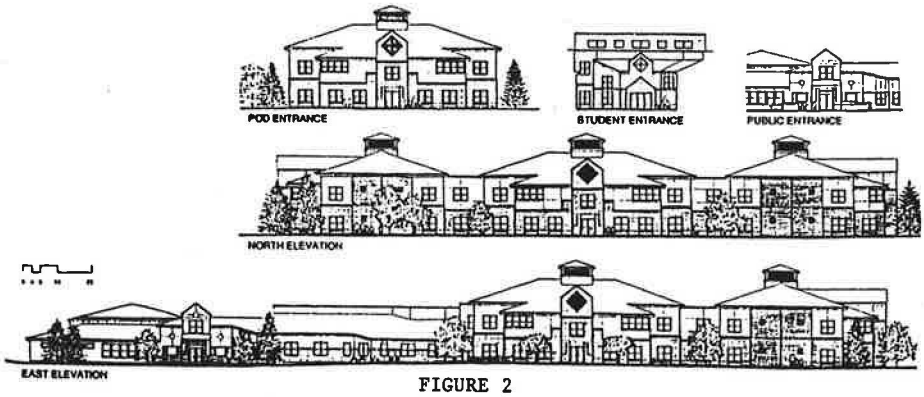

FIGURE 2