BUILDING ENVIRONMENT MODIFICATION: AN EXPERIMENTAL STUDY

E.D. McIntyre and E.M. Sterling
TDS Limited, #70, 1507 West Twelfth Avenue, Vancouver, B.C. V6J 2E2
(604) 733-2701

Presented at the Indoor Air Conference Northwest Center
for Occupational Health, University of Washington
Seattle, December 7-9, 1982

The large, tall office building has been in existence as a building type for nearly a century. The majority of those constructed in the last 40 years have been typically sealed, mechanically heated, ventilated and air conditioned. These buildings can be accurately described as containers of manufactured environments. The reasons underlying the widespread use of mechanical systems in this building type have more to do with architectural aesthetics than functional necessity. In fact, the Equitable Building, the first completely sealed, mechanically heated, ventilated and air conditioned building constructed was also one of the earliest North American examples of the Modern or International architectural style. The extensive use of glass inherent to this style resulted in environmental problems. Architectural response to these problems would have significantly altered the design aesthetic, therefore mechanical systems were introduced.

Since 1974, there has been an increased incidence of building associated health complaints (Building Illness) from occupants of this building type.[1,2,3] Building Illness is now considered an epidemic by some public health experts. Appearance of Building Illness coincides in time with a concerted effort to minimize building energy use by reducing fresh air ventilation and expanding acceptable ranges of temperature and humidity.[4]

Research investigating the causes of Building Illness has identified six building features as relevant to the incidence of Building Illness. Significantly these features are typical primarily to buildings with mechanical environmental control systems. These six features are:[5]

1. A hermetically sealed, airtight shell.
2. Mechanical heating, ventilation and air conditioning systems.
3. Utilization of new materials and equipment which give off a wide variety of irritating and sometimes toxic fumes and/or dust.
4. The use of fluorescent lamps that emanate ultraviolet light which provides energy for photochemical reactions among pollutants that form the basis for photochemical smog.
5. The application of energy conservation measures.
6. A lack of individual control over environmental conditions.

The implication of this information is clear - the majority of office buildings constructed since the 1940's may represent a significant health hazard to their occupants.

As awareness of Building Illness becomes more widespread, it is going to have a dramatic effect upon the willingness of people to occupy these environments. Obviously, changes will have to be made to qualitatively improve the environments within existing sealed buildings.

The first step toward defining the nature of the requirement modifications is the generation of a model establishing the design constraints for a nonhazardous building environment.

We compared the health and comfort of the environment within a sealed, mechanically ventilated and air conditioned building to that in a nonsealed, naturally ventilated building. The purpose was to evaluate the environmental quality of sealed versus nonsealed buildings.

This study demonstrated that user satisfaction with, perception of, and performance within, a nonsealed building was significantly better than that in the sealed building.[6]

The design constraints which determined the architectural form of the traditional, non-sealed building were as follows:

1. Architecture which shields the building interior from undesirable aspects of the environment while tempering and/or admitting usable environmental resources.

2. Utilization of nonarchitectural environmental modifiers as necessary and/or desirable.

3. Evaluation of and environmental response to highly polluting activities, equipment and materials.

Due to the demonstrated success of these design constraints with regard to nonhazardous and comfortable built environments, they serve as the basis for determination of modification to an existing building design. The adoption of these constraints as the model does not imply a return to construction of buildings strictly modelled on early Twentieth Century historical models. The environmental demands which man now makes of his buildings, and his vastly increased body of knowledge and technological abilities, make such a course both impossible and irrational. It is, rather, an opportunity to synthesize the sound conceptual basis of traditional building design with the technological capabilities of Twentieth Century man.

Building Modification Design Problem

The model was applied to a theoretical design problem: improvement of environmental conditions within a sealed office tower through building modification.

The building used as the basis for the design problem is a sealed, mechanically heated, ventilated and air conditioned office building now under construction. The building is essentially a high vertical tower sitting on a landscaped plaza and, as such, is typical of most modern office complexes.

This building possesses four of the building features relevant to the incidence of Building Illness:

1. a hermetically sealed, airtight shell;

2. utilization of new materials and equipment which give off toxic dust and/or fumes, although provision has been made for separate removal of pollutants generated by equipment;

3. a mechanical heating, ventilation and air conditioning system;

4. standard fluorescent fixtures for lighting interior office spaces.

In addition, the location of the supply and exhaust vents is problematic as pollutants such as diesel fumes and carbon monoxide may be inducted into the vents overlooking the street. Once in the building, these pollutants maybe trapped, and accumulate to unacceptable levels. Rooftop vents are located in a well and air pressure could make it impossible for the exhaust air to escape, thereby causing it to be drawn back into the ventilation system. Also, the perimeter zone receives no direct supply of fresh air. This is the area most likely to be partitioned off into executive offices, offices which will receive no fresh air at all.

To best eliminate these problems, the architectural model implies adjustment of the building architecture to optimize utilization of environmental resources.

The simplest means of effecting this would be the installation of operable windows but, in a tower located in a downtown district, this might open the building to a host of environmental problems, including wind, dust and noise. In consideration of such, the optimal solution would be one which incorporates the benefits offered by traditional windows, but which has been modified to reduce dust, wind and noise penetration. In addition to ventilation, heating and cooling could also be incorporated into window function.

Other architectural modifications to minimizing dependency upon mechanical systems include: screening of facades exposed to direct radiation and maximization of the penetration of daylight into the building interior through reflection techniques.

Conclusion

If modifications as described were made to the case study building, the likelihood of incidence of Building Illness would be reduced drastically, as the potential hazards would be eliminated or minimized by the improved ventilation system. Significant energy savings would also ensure as the building would rely on non-energy consuming environmental modification techniques as much as possible.

References

1. Baxter, P. J. (1980). Paper on biological substances and indoor air quality, prepared for the subgroup for health effects on indoor pollution. Proceedings, U.S. Government Inter-agency Research Group on Indoor Air Quality; Workshop on Indoor Air Quality Research Needs, Leesburg, Virginia, December 3-5.

2. National Research Council (1981). Indoor Pollutants. National Academy Press, Washington, D.C.

3. International Symposium on Indoor Air Pollution, Health and Energy Conservation, Amherst, Massachusetts, October 13-16, 1981.

4. American Society of Heating, Refrigeration and Air-Conditioning Engineers (1975). Energy conservation in new building design. ASHRAE Standard 90-75. Atlanta, Georgia.

5. Sterling, T. D., Sterling, E. M., and Dimich-Ward, H. Indoor Pollution Related to Building Energy Conservation. Presented at the Annual General Meeting of the Northwest Chapter of the Air Pollution Control Association, Vancouver, B.C., Nov. 15-17, 1982.

6. Sterling, E. and Sterling, T. The impact of different ventilation and lighting levels on building illness: An experimental study. International Symposium on Indoor Air Pollution, Health and Energy Conservation, Amherst, Massachusetts, 1981.