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Buildings, Ventilation and Thermal Climate

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ARCHITECHNOLOGY: AN ARCHITECTURAL-TECHNOLOGICAL INTEGRATION FOR IMPROVED ENVIRONMENTAL QUALITY IN BUILDINGS

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Abstract

Contemporary office buildings may be unable to provide safe and comfortable environments without tremendous expenditure on energy. Yet contemporary office building architecture and environmental control technology have become the keystones of the evolution of architectural and environmental control theory in the modern industrial age. Sealed energy efficient technology which is apparently responsible for the epidemic rate of health and comfort complaints is now being adapted for use in other building types, including residences and even hospitals. The authors propose to present an alternative architectural theory of building environment control, based upon Architechnology, the integration of contemporary architecture and environmental control technology into a building system utilizing both to maximum efficiency as defined by functional performance, energy utilization and human comfort.

Energy Efficient Sealed Building Evaluation

Figure 1 illustrates a plan of a typical floor in a contemporary sealed energy efficient office building now under construction in a Canadian city. The multi-million dollar project consists of a 30 metre square tower, a landscaped plaza and an underground parking garage.

The office tower has a sealed envelope and functions as two distinct environment control systems: an upper and a lower system with supply and exhaust air vents located respectively on top and near ground level (overlooking a busy downtown street). Intake air is preliminarily filtered and tempered, then dispersed through large central ducts to mechanical rooms on each floor. Every floor is divided into environmental zones. A variable air volume system supplies a varying volume of air tempered to constant standards to the perimeter area of a floor (that portion within 4 metres of an exterior wall). A constant volume system supplies a constant volume of air tempered as required to the remaining area, or interior zone of floor space.

Upon entering the mechanical room on each floor, the Fresh Air is mixed with the interior zone recirculating air. The mixed supply air is treated to interior zone temperature and humidity requirements and then blown through ducts and ceiling diffusers to the interior zone. Return air from the interior zone returns to the mechanical room through the ceiling plenum, is retreated and distributed to the perimeter area of each floor. Some air, balanced in volume to equal the volume of fresh air introduced into the floor ventilation system is exhausted. Lighting is provided by fluorescent ceiling fixtures and natural daylight through perimeter windows.

This typical environmental control system contains eight building characteristics, all identified by research (1) as antecedents of serious health and comfort complaints in buildings.

1. Pollutants which enter into a sealed building envelope with the fresh air, and those which are generated within the building environment itself are dispersed throughout by the mechanical ventilation system. The relatively small volume of air which is exhausted from the building to balance the intake of fresh air carries with it only a fraction of the airborne pollutants contained within the total (2).

2. The mechanical heating, ventilation and air conditioning (HVAC) system aids dispersal throughout the building of irritating pollutants, incubates and spreads fungi, bacteria and viruses (3,4). Additionally, HVAC system insulation materials have been identified as a major source of fibres found in sealed system environments.

3. Ultraviolet light from fluorescent lamps provides energy for oxidation reactions among pollutants forming the basis for indoor photo chemical smog production (5).

4. The inability of occupants to control and modify the standardized environment is related to occupant dissatisfaction (6).

5. The placement of the building air supply and exhaust vents in a roof well often results in induction of exhaust air back into the building when natural environmental phenonena, such as winds, interrupt airflow patterns. Air intake vents located near the street inducts air heavily contaminated by street traffic.

6. Location of both room air supply and exhaust vents in the ceiling results in poor ventilation. The air entering the space usually does little more than pass across the ceiling, effectively leaving the occupied space unventilated.

7. As direct introduction of fresh air to the perimeter supply air has not been provided for, the prospect is a series of closed perimeter offices with no supply of fresh air whatsoever.

8. Locating the parking garage beneath the building leads to infiltration of occupied spaces, by means of the elevator core, by air contaminated from automobile exhaust.

Our analysis of this typical sealed energy efficient building has obvious implications. Given existing knowledge of their performance, the building described, a structure typical of current design practice, will in all likelihood present serious environmental health and comfort hazards to occupants. Nevertheless, sealed energy efficient buildings continue to be built. Further, sealed energy efficient building technology, until recently almost exclusively associated with commercial office buildings, is now being adapted for use in residential environments and for many new hospitals.

Despite the fact that building technology, office practice and world energy supply have undergone fundamental changes, architectural environmental control theory seems not to have risen beyond sealed building theory as first proposed by Corbusier over 50 years ago (7). The reason for the apparently irrational continuation of the sealed building tradition appears to be linked to the failure of contemporary architects to deal with the contemporary problems associated with sealed building design. While sealed building theory was proposed by architects, the actual design of mechanical systems was the achievement of engineers, notably Carrier (8). The dependence of architects on engineers for the design of mechanical systems separated the design of environmental control systems from the traditional practice of architecture. Prior to the introduction of sealed HVAC systems theory, the architect relied primarily upon the building architecture to define and manipulate environmental conditions. The architectural system was then supplemented by mechanical systems as necessity and man's technological capabilities allowed. Given the inadequacies of contemporary sealed systems and the traditional role of the architect as the definer of the means and actual systems of environmental control, it would be appropriate to generate an alternative, architectural, theory of building environment control.

Architechnology Defined

In defining the attributes and limitations of architectural and sealed environmental control systems, a significant symmetrical relationship becomes apparent. Occupants find architecturally controlled environments more comfortable (and they perhaps are also healthier) than sealed energy efficient environments. Sealed energy efficient environments controlled by mechanical systems offer more precise control of indoor environment conditions. Architecturally controlled environments, through primary reliance on passive means of environmental control, may be inherently more energy efficient than sealed systems which rely totally on energy resources to achieve environment control. It would seem that the ultimate comfortable and efficient environment control system would be one which combines the advantages of both architectural and technological systems.

Contemporary approaches to achieving energy efficiency attempt to reduce energy consumption in every building everywhere. A more rational architechnological means of conserving uses energy where and as

necessary to create healthy and comfortable environments. This implies use of passive architectural means of environmental control to full effect. Contemporary technology however should be used not only to supplement the architectural system, but as an integral part of the system. Architechnological building can then be defined as an environment control system utilizing architecture and mechanical system technology to maximum efficiency as defined by occupant health and comfort, energy efficiency and the indoor and outdoor environments.

Architechnology: A Design Solution

Figure 2 is a typical floor plan illustrating an architechnological solution for an office building of the same scale and on the same site as the building illustrated in Figure 1. The climate is temperate oceanic with average temperature range 0 - 20° with heavy rainfall.

Ventilation. To avoid the problems associated with a sealed building envelope, an architechnological solution dictates a permeable building envelope allowing air flow in, through, and out of the space by means of the building envelope. This implies the use of some form of operable air vents or "windows" as a means of supplying fresh air. Additionally, adequate ventilation can be achieved by natural ventilation which, in turn, dictates design of the floor plan for minimizing interruption of air flow by interior partitions. The removal of the core from within the building volume eliminates a major potential obstacle to air flow. By varying floor areas within, potential for every floor to have a single tenant would be maximized thereby reducing the need for partitions of space.

Thermal Environment Control. Particularly in office towers, the major function of standard HVAC systems is to counteract the tremendous heat generated by lighting and equipment as well as the activity of building occupants. Therefore, ventilation also would probably suffice to create comfortable conditions most of the time. Heating and cooling and humidity control of the air would be handled by units integrated within the window itself including shunting of airflow to and from warmer and cooler sides of the building. The ventilation rate and air temperature could be controlled in part by the occupants' using adjustable louvers and/or keyed to a computer controlled self adjusting system. The need for total thermal control of the environment by energy utilizing mechanical systems can, however, be minimized by architectural response to and protection from extreme outdoor conditions. In addition, the cooling effect associated with natural ventilation may provide sufficient environment modification.

Lighting. A narrow building section reduces the need for dependence on artificial lighting. Limiting the width of the building to a maximum of 12 metres would ensure full penetration of daylight from both sides of the building. At night, general illumination could be provided by fluorescents operated manually by occupants, eliminating waste lighting now common due to single circuit control of large blocks of lighting. During both night and day, supplementary

lighting would be provided by manually controlled task lighting.

The concept of achieving energy efficiency through reliance on passive systems dictates maximum utilization of natural daylighting resources. Buildings conceived to maximize daylight penetration have all general illumination required during daylight hours provided by non energy consuming means. By eliminating total dependence on artificial light sources, problems associated with inexpensive and efficient lighting provided by fluorescents would be minimized.

Space Utilization. As much as 25% of the total volume of a building is occupied by space for the duct work serving the HVAC system. Once that duct work is eliminated, much of this space may be recovered through increase of the number of rentable floors.

Conclusion

The practice of sealing buildings serviced by mechanical HVAC systems arose primarily from the necessity to achieve energy efficiency. Changing world energy resource markets forced adaption of sealed building design to energy efficient standards in order to maintain building economic viability. But the means of achieving energy efficient sealed building systems have unavoidable detrimental effect upon environmental quality. Contemporary energy efficient sealed buildings serviced by mechanical HVAC systems may be a failure. The sealed energy efficient HVAC serviced building may be an anachronistic relic. In short, the time may have come to publicly question the reigning emperor's state of dress.

There now is known a great deal about conditions governing airflow and determining qualities of ambient air. Many of these factors can be manipulated to achieve a desirable state. We also have realized the reasonable limits for many air contaminants of what indoor air can achieve. That is often a set of conditions parallelling what is found outdoors. Incorporating all that has been learned, architechnology, the blending of architectural design and technology into an integrated science of environment control, offers a sane and energy conserving solution. To minimize costs, architechnology relies on the scientific control of factors determining environmental conditions and to optimize human pleasure, architechnology seeks to incorporate environmental control into useable spaces.

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