Indoor Air Quality

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BUILDING ARCHITECTURE AND BUILDING AIR QUALITY

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1.0. INTRODUCTION

Providing an appropriate and desirable environment within buildings has always been an implicit objective in architectural design. However, the definition of what conditions are deemed appropriate and desirable has a history of reassessment and refinement as have the methods and technologies by which they can be achieved.

During the past century, power driven systems have replaced the building envelope as the principal means of environmental control. Providing uniform conditions by automated environmental controls has become the dominant concept. The assumption that one environment is universally acceptable has resulted in a change from individual control integrated with the building to independent central control systems. The requirements of climate

control systems conbined with the intent to provide uniform conditions has resulted in buildings which are sealed and where climate is centrally controlled. As a result individual occupants of buildings are less and less capable of making voluntary changes to meet what they perceive as their own needs.

During the same period, the proliferation of new synthetic building and furnishing materials and office equipment introduced significant, but unrecognized, sources of internal contamination.

The magnitude and abruptness of the shift in energy concerns over the past decade clearly demonstrated the extent to which buildings have become dependent on ample energy to power mechanical ventilation systems. In both America and Europe, initial response to the energy crisis precipitated substantial changes in legislation and standards affecting building design and operation. The building envelope became more airtight and insulated. Operating protocol, acceptable temperature ranges and ventilation rates, became dictated by energy efficiency criteria rather than comfort. Inappropriate adherence to these criteria has aggravated indoor pollution.

In addition to energy, contemporary office design has been dramatically influenced by a tight economic environment. Under the pressure of reduced design time and capital, design decisions are more exacting and there is less room for error. The rapidly developing technologies of building materials, building systems and components, fast-track construction methods, and designs have created a plethora of potential architectural hazards to occupant health and well being (1). The result of these pressures and new technologies has been an attendant increase of occupant health and comfort complaints in new and newly renovated buildings. Tenant complaints have prompted interest among building owners and operators in increasing environmental quality in offices. In turn, this interest has made environmental quality and comfort in buildings an increasingly explicit design issue. As the causal relationship between buildings and environmentally induced illnesses has become established, there has been a parallel increase in litigation. In fact, a recent articule in the Journal of the American Institute of Architects suggests that the area of most serious potential concern to architects and engineers is that of indoor environmental quality. (2)

2.0. AIR QUALITY AND BUILDING DESIGN

The building environment is multifaceted. It includes components such

as temperature, lighting, noise level, as well as the physical characteristics of the building and use of the space. Environmental quality embodies all of these factors. Due to their interaction and the fact that the significance of the various aspects of the environment varies from person to person and from activity to activity, environmental quality is difficult to define in precise terms.

The quality of the environment directly and indirectly affects a person's well-being, mood and effectiveness at pursuing various activities. The overall impression that occupants have of their own environment will influence their satisfaction with, and acceptance of the space. This, in turn, will affect performance (3,4).

Over the past few years several studies have established the relationship between environmental conditions in office buildings and occupant comfort, health and performance.

User Preference Studies

When compared with a variety of other parameters affecting satisfaction in the workplace, including salary and ergonomics, environmental conditions are judgedas priority concerns (5). An office building that does not achieve adequate environmental conditions can affect not only the health of occupants but also office productivity. If building occupants are satisfied with their indoor environs, the prevalence of health complaints is lower, truancy is decreased and the work place is generally more productive. This has been demonstrated in one study of office workers before and after their company relocated to a modern-type office building with poor environmental conditions. Absenteeism dramatically increased related to the prevalence of health and comfort problems after relocation (6). These same factors causing health and comfort problems may also have reduced office productivity. For example, in a recent study Robertson showed that improving environmental conditions in a typical 100,000 square foot office building could realize a saving of $100,000 per year in increased productivity (7).

Problem Buildings

Numerous studies have been undertaken in buildings in which occupants have expressed that they were suffering from building related illness or discomfort. The principal finding has been that inadequate ventilation is the

primary cause of health and comfort problems (8, 9, 10). In fact, a study conducted by Firemen's Fund Insurance found that increasing the fresh air ventilation from 5 to 25 cfm per person in an office building resulted in a 40% decrease in complaints of health and comfort problems (11). Although not documented, such a dramatic increase in satisfaction with environmental conditions provided in an office building would undoubtedly have an impact on the absentee rate for firms occupying that building.

These studies present a clear directive to the building owner and architect and reaffirm that occupant comfort and well-being must be priority goals in office design.

3.0 DESIGNING BUILDINGS FOR ACCEPTABLE INDOOR AIR QUALITY

Maintaining high quality indoor air is a fundamental necessity for human health and comfort. Ventilating buildings with acceptable outdoor air to replace exhausted air is the usual means of controlling the build-up of air contamination and odours from human respiration and activities, as well as from building materials, office equipment and other processes. Air quality is strongly correlated with building occupant satisfaction, comfort and productivity and is an immediate health concern particularly in sealed buildings (12, 13).

Indoor air quality depends on:

- The efficient exhausting of contaminants and odours produced in the space by respiration and other activities, building and finishing materials and all processes occurring there.
- A source of outside air of acceptable quality.
- The control of unwanted infiltration of contaminants from outside and emanations from interior materials, processes and chemical and biological sources from the inside.

Building occupant satisfaction with indoor air is dependent upon many factors and individual variables including:

- The extent to which indoor air is perceived as "fresh".
- The temperature and humidity of indoor air, and the amount of perceived air movement.
- The degree of personal control over the environment.

4.0 CONTROLLING INDOOR AIR QUALITY

The following issues and strategies are intended as a guide for architects concerned with provision of acceptable indoor air quality in buildings.

4.1 BUILDING STANDARDS

It is becoming increasingly important that architects be explicit in the specification of environmental conditions within office interiors. However, being able to provide such specifications requires an understanding of both the literature and the standards governing these areas of concern. Standards governing environmental quality criteria in buildings and "good" practice for achieving them are typically established either by governments or within the respective professional organizations. Such standards represent the synthesis of research in specific areas, evaluated by committees against issues of cost and practicality.

The use of standards requires some understanding and interpretation:

- Environmental standards typically address only those parameters which are most easily defined, specified, predicted or measured. Many of the quality aspects of the environment do not lend themselves to such reduction.
- Standards provide a designer with a guide for achieving environmental conditions. The interpretation of the standards in the context of a specific problem is a more critical issue. In this regard it is clearly not possible for a designer to be fully conversant with the assumptions and contexts of the original research on which a standard is based. However, the absence of such information makes the interpretation that much more difficult.
- Standards are often treated as design values to be merely achieved rather as design minimums which should, in most instances, be exceeded.
- Environmental quality standards define a range of conditions deemed acceptable for the majority of occupants.
- Standards and codes take considerable time to both formulate and revise and thus invariably lag behind scientific knowledge. The process is typically evolutionary with incremental changes made within an ex-

isting framework. In evolving areas of concern that may not yet be specified in standards, the design professional must understand the current debate and anticipate potential changes to standards.

4.2 EXTERNAL CONDITIONS

To achieve good air quality indoors, the quality of the outdoor air must first be assessed to determine how it will be used.

Building design should be influenced by outside air movement. Buildings should be situated so as to minimize the negative effects of the surrounding environment such as pollutants emitted from adjacent industry, transportation and agriculture. It is also necessary to evaluate the effect the proposed building will have on air movement to avoid re-entrainment of building exhaust, contamination of adjacent public open spaces and the fresh air supply to surrounding buildings.

4.3 INDOOR CONDITIONING

Activities and Processes

Office equipment and supplies, occupant activities, parking garages and loading docks, printing areas and other activities within the building are sources of air contamination. Local exhaust for contamination sources will minimize their impact on indoor air quality. Also airlocks and pressurization will reduce the entry of vehicle exhaust and other outside contaminants.

Building Materials

Many building material such as asbestos, urea formaldehyde insulation and preservatives are sources of indoor air contamination and introduce significant health risks to the environment. These problems are not difficult to identify, and there is a developing body of reliable information available on most building products.

Often building maintenance practices introduce hazardous products which can become airborne, such as insecticides, within the environment.

4.4 BUILDING HVAC SYSTEMS

The provision of acceptable outside air and the exhausting of contaminated air may be managed by natural or mechanical means or an integrated combination of both. A natural ventilation system is only appropriate where temperature is mild and outdoor air is clean.

Where the ambient air is not of acceptable quality a natural ventilation system is not appropriate. In these cases a completely mechanical ventilation system with appropriate makeup air treatment will be necesary. However HVAC systems can themselves contribute problems if not properly designed and maintained. This is especially important in systems that include humidification. Wetted materials and standing water can provide suitable habitats for breeding micoorganisms that can pose serious health threats to occupants. Well designed systems minimize this risk, but good maintenance is also necessary. Visible and easily accessible maintenance points, and a system operating manual including a maintenance schedule and list of checkpoints is a basic requirement for training of operating staff. Providing this information should be a responsibility of the design team.

HVAC system commissioning is an essential part of assuring system performance. Many air quality problems are due to inoperative equipment, faulty cycling and poor pressure balancing. These faults can also account for excessive energy consumption.

A complete commissioning procedure will require checking that all system parameters comply with design values and that all controls are installed and operating as specified. Commissioning is not only necessary for new buildings but is also required after building or system alterations.

Humidity Control

Controlling humidity is a significant contamination control issue (14). The outgassing of contaminants such as formaldehyde in building and finish materials progresses more rapidly at higher humidity and temerature levels.

Levels of biological activity are also increased by high humidity, and human susceptibility to airborne microorganisms is increased by low humidity.

Buildings which are maintained at 40% to 60% R.H. provide the most beneficial conditions for occupants, building materials and building contents

(15). In order to achieve humidity control without condensation damage, buildings must have air/vapour barrier protection and insulation of cold pipes and chilled air ducts.

Temperature Control

On the basis of current research, effective control of the thermal environment may be the single most significant factor defining the thermal comfort and satisfaction of occupants.

Local controls in zones that are as small as practical are the best strategy for comfort and satisfaction and may contribute to energy savings. They are, however, more costly to install. Controls must conform to office partitioning for effective function. Where changing space use cannot be fully anticipated, a flexible system allowing adaptation will be the most effective in the long term. Occupant satisfaction is also enhanced when controls are readily visible and comprehensible. Wherever possible the control should be visible from the space it is connected to.

5.0 DISCUSSION

Traditional Building design has achieved a balance between:

1. Satisfying architectural requirements;
2. Minimizing energy and operating costs;
3. Minimizing initial construction costs.

While design criteria for occupant comfort and well-being can be integrated with these traditional design considerations, starting with them may eliminate or severely compromise the potential for achieving a quality indoor environment.

Providing appropriate air quality conditions within office buildings is a direct result of the interaction of design professionals and related occupations. Many of the building performance problems involving these components are typically a direct result of poor co-ordination between all those involved in design and construction. These problems are, in part, the product

of a design and delivery process which does not view a building as a total system.

Environmental quality requires the successful integration of criteria and not their assemblage, systematic or otherwise. To achieve both environmental quality and energy efficiency, the following general principles are advocated.

- All strategies and choices should be made with regard to their impact on people. Issues of cost should be considered after a clear evaluation and statement of how occupant needs are to be satisfied.
- The control strategy should be responsive to use requirements, time, natural variation and changing occupancy.
-Architectural or passive techniques should be used to modify the external conditions to provide a base line indoor environment. Power operated controls should then be used to "fine-tune" the indoor conditions.

Moreover:

- Mechanical and lighting consultants must be involved with the project from the outset.
- A measure of redundancy should be built into the environmental controls strategy for the building. The systems should be kept simple and fail safe, and their design anticipate both mechanical failure and human failure.
-Design decisions which have an impact on environmental quality should be followed through sufficiently to understand their interconnection.

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