"BUILDING SICKNESS"

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INTRODUCTION

Thank you.

Since 1978, I have been Research Specialist, Center for Environmental Design Research, College of Environmental Design, University of California Berkeley where I have also Taught in department of Architecture. I taught at UC Santa Cruz, in the Board of Environmental studies for four years.

I am the Chairman of recently established ASTM Committee on Indoor Air Until last month, President of the California Board of Architectural Examiners on which I served since February of 1977.

DEFINE BUILDING SICKNESS

"Sick" building syndrome, was recognized prior to 1960. Building sickness, the subject of my presentation, is part of a larger phenomenon, Indoor pollution. The term "indoor pollution" came into commmon usage in the late 1970s, and in 1978, the California State Department of Consumer Affairs held two days of public hearings on the subject. A report, Clean Your Room, was published in 1982. In 1980, the General Accounting Office of the federal government issued a report describing the problem and warning of its seriousness.

* [Figure 1] Building Sickness, or (sick building syndrome):

Definition: The 1983 World Health Organization publication, Indoor Air Pollutants: exposure and health effects, defines ~~indoor pollution~~ building sickness as having many common features usually including the symptoms listed in the first

table. These symptoms have been widely reported in Scandinavia and ;the United States in association with the interior environment. Between 15 and 30 % of the population surveyed in a Danish study reported the symptoms shown in the table.

* [Fig. 2] Peachtree tower, Atlanta

BRIEF HISTORY

Early in the 1970s, after two decades of attention on ambient air pollution, measurements comparing indoor and outdoor levels indicated that indoor air quality was often worse than outdoor air during severe air pollution episodes. Offices, residences, schools were all monitored. Then the Arab oil embargo resulted in energy conservation which, in buildings, meant, among other things, tighter sealing around doors and windows, additional thermal insulation, vapor barriers, and reduced ventilation to conserve energy required to condition outdoor air.

Modern building materials, furnishings, equipment, and consumer products have increased ~~their~~ dependence on synthetic organic chemicals since the end of World War II. Now nearly every aspect of modern life is highly dependent on such chemicals, and our technological achievements include providing human environments capable of withstanding the extremes of

* [fig.3] Primitive tropical dwelling

tropical heat,

* [Fig. 4]

arctic cold,

* [Fig. 5] foil suit

industrial processes

* [6] sea diver

great atmospheric pressure

* [7] astronaut
and the non-atmospheric environment of outer space.

* [8] clean room

* [9] clean room worker

Our ability to provide clean indoor environments has been developed to a very great degree in recent years with the requirements of electronics and biotechnology research and industries.

Because ~~Since~~ buildings require about 37 percent of the nation's energy use, substantial public and private investments were made to achieve energy use reductions through conservation measures.

* [10] Poisoning of America

The awareness of general environmental pollution was extended to our waste dumps in the 70s and now, in the 80s, there is increasing awareness that indoor pollution from a variety of sources was far greater than previously realized.

* [11] Indoor Pollution

* [12] Cave man 38,000 years ago

Indoor pollution, however, is not a new problem. It dates from the time of the first caveman (or woman) using fire inside the cave.

* [13] Forms of indoor pollution

Noise and other mechanical vibration. Light and other electromagnetic radiation. And air pollutants - chemical, biological and physical.

* [14] Sources of indoor pollution

Sources exist outdoors and carried inside intentionally by building ventilation systems, or inadvertently, by infiltration or people.

Sources exist inside include materials, furnishings, equipment, appliances, consumer products, and, the metabolic process of people.

* [Figure 15] Pollutants of concern

This figure shows the World Health Organization Working group on Assessment and Monitoring of Exposure to Indoor pollutants rank ordering of indoor pollutants according to level of concern based on their known concentration and distribution in the indoor environment and on their human health effects.

As you can see, tobacco smoke is at the top of the list. Combustion by-products from unventilated or poorly-ventilated gas appliances follow. ~~Then~~ radon, ~~it~~ is estimated to cause between 2 and 20 thousand excess lung cancer deaths per year from indoor exposure, mostly in residences located in regions where background levels are high.

Formaldehyde is an important industrial compound, widely used in buiding materials furnishings and consumer products.

* [17] Biological effects of common indoor pollutants (~~unpublished report~~ Proceeding. Indoor Air '84)

Lars Mølhave of Denmark has analyzed 62 compounds commonly found in a large number of building investigations and found that 36 % are suspected and 48 % are known mucous membrane or eye irritants, a total of 84 % are known or suspected agents in Building Sickness. Many are also suspected carcinogens, 5 suspected or known human carcinogens.

* [Figure 18] Clerical worker with mask

The problem of indoor pollution has increasingly been recognized in offices, schools and residences. Today we will look at two studies of office workers.

* [19] ACGIH: Evaluating office environmental problems. Atlanta: ACGIH. 1984.

NIOSH OVERVIEW

First, let us look at some summary data from the National Institute of Occupational Safety and Health, part of the Center for Disease Control.

APPENDIX

LIMITATIONS ON INVESTIGATIONS

Time delays between on-set of symptoms and initiation of investigation, air sampling, clinical studies, epidemiologic studies

Resource constraints

Technical constraints: measurements cost, accuracy, representativeness, etc.

Connections between reported symptoms and complaints and measured environmental parameters.

Combined effects - Potential synergy

Large number of related factors which can affect environment or its impact on occupants.

LIMITATIONS ON PHYSICIANS

Absence of awareness, training.

Reporting of patient: accuracy, awareness, intimidation.

Similarilty of symptoms to those caused various agents including many others in the environment. Absence of precise relationships between enviornmental agents and symptoms.

POTENTIALLY SIGNIFICANT EFFECTS/CONSEQUENCES

Chronic illness.

Increased rate of respiratory illness

Cancer.

Defective births.

General malaise, fear, dissatisfaction.

RESEARCH NEEDS

Systematic, comprehensive building investigations with adequate measurement of environmental and health factors

Further definition of health effects of indoor pollutants

Dose studies of exposed populations

Control measures evaluation

Health effects reporting mechanisms

In a meeting held in Atlanta in 1983, the data shown in this table was presented by the director of the Health Hazard Evaluation Program of NIOSH which reports a significant increase in requests for Health hazard evaluations during the late 70s and early 80s, just about the time that energy conservation efforts in buildings were coming to fruition in the form of completed new buildings designed with energy conservation standards, the retrofitting of existing buildings, or the modification of operating procedures usually involving a reduction in building ventilation. In some instances, buildings were sealed or windows in schools were bricked to reduce outdoor air infiltration.

* [Figure 21] Frequency of symptoms among 285 office employees

In another paper from the Atlanta meeting, Dean Baker of the UCLA School of Public Health reported findings of a survey of 285 office workers in a typical investigation. While "...prevalence of complaints is high, the pattern is not indicative of exposure to one or a few toxic agents."

* [22] Stress and office worker

Often the problem is attributed to social and psychological factors associated with the job. However, studies have shown that these factors alone cannot account for the excess number of reported instances, as shown by the following two case study reports.

* [23] Title: The effects of reduced ventilation on indoor air quality in an office building. Atmospheric environment, vol 17, no. 1, pp. 51-64. 1983.

* [24] [25] Exterior of SFSS Building

The SAN FRANCISCO SOCIAL SERVICES BUILDING represents an early instance of a building investigation which includes both air monitoring and epidemiology. A familiar pattern was seen. Shortly after occupancy, workers began to complain of the familiar symptoms.

* [26] [27] interior of building

Some workers visited the San Francisco General Hospital Occupational Health Clinic where physicians recognized that a problem might exist due to their ~~common~~ shared workplace. An employee union distributed a questionnaire. The results pointed to problems in the building.

* [28] Comparison of health related complaints in SFSSB and control

An epidemiologic study by ~~the regional~~ Dr. Molly Coye NIOSH staff member indicated that ~~problems~~ the complaints were related to occupancy of the building. The results are unequivocal, and the symptoms were typical of "building sickness."

* [29] Air monitoring data

Air monitoring conducted eight months later was not definitive, although ventilation efficiency problems were found.

* [30] Building plan

* [31] CO_2 data all outside air mode

* [32] CO_2 data recirculation mode

* [33] Carbon dioxide levels and occupant responses (Rajhans, Canadian Journal of occupational health)

* [34] Formaldehyde levels in two ventilation modes

* [35] Formaldehyde health effects thresholds (National Academy of Sciences, Formaldehyde and other aldehydes)

* [36] Building section showing ventilation system in ceiling

Ventilation efficiency is the ability of the system to distribute air to the breathing zone, to mix air well throughout the space. A short circuit was discovered between inlet and outlets, particularly when supply air was not cooler than the air already in the space, thus tending to remain in the upper portion of the space.

* [37] The sick building syndrome: prevalence studies (Finnegan et al, British Medical Journal, Volume 289, pp 1573-1575. December 8, 1984.)

A comprehensive study of nine buildings in England was reported in the December 8, 1984, British Medical Journal.

* [38] Table 1. Details of buildings and populations studied in each. The investigators interviewed a large percentage of the populations in each of nine buildings. The study began with a so-called "problem building" and a control on the same site. The usual symptoms were reported and were found statistically significant. Additional buildings were studied in pairs, naturally and mechanically ventilated at the same site. The results are presented in the following three tables.

* [39] Table 2. Prevalence of symptoms (%) in relation to method of air supply - comparison with natural ventilation.

NASAL symptoms include

blocked, itchy or runny nose

EYE symptoms include
Itching, irritation, watering eyes

MUCOUS MEMBRANE symptoms include
dry throat, stuffy nose

symptoms suggestive of work related asthma include
CHEST TIGHTNESS

DIFFICULTY IN BREATHING or SHORTNESS OF BREATH

WHEEZE

and symptoms suggestive of HUMIDIFIER FEVER include
Fever, joint and m;uscle pains, tiredness, headache

* [40] Histogram For data in Table 2

* [41] Table 3. Prevalence of symptoms (%) in each building studied

* [42] Histogram with numbers and p values for findings

Findings:

"Headaches and lethargy are very common complaints. It was therefore surprising to find such highly significant differences ($p<0.001$) between naturally ventilated buildings and those with mechanical ventilation with or without humidification."

"Another symptom that was in excess in the humidified buildings was chest tightness." Peak flow rate measurements did not show any evidence of work related asthma. "The cause of this symptom in the air conditioned buildings is not clear."

"As would be expected, humidifier fever was commoner in humidified than innon-humidified buildings."

"Finally, although the symptoms of the sick building syndrome do not represent a disease but rather areaction to the working environment, the scale of the problem is probably considerable, and the high degree of dissatisfaction seen in this study demands attention from architectects, engineers, and the medical profession. In particular, more research is needed, preferable of a longitudinal nature, into both air conditioned and naturally ventilated buidings."

* [43] Major research contributions to indoor air quality
* [44] principles of ecology
* [45] Building ecology

CONCLUSIONS

The World Health Organization ~~has published a~~ report suggesting that there are temporarily and permanently sick buildings. No obvious causes are generally found. That such buidings have the following characteristics:

1. They nearly always have forced ventilation systems.

2. They are often relatively light consturction.

3. The indoor surfaces are often covered with textiles, carpets and other materials with a high surface to volume ratio.

4. They are energy-efficient, kept relatively warm, and have a homogeneous thermal environment.

5. They are characterized by airtight building envelopes (in the United States, windows cannot be opened).