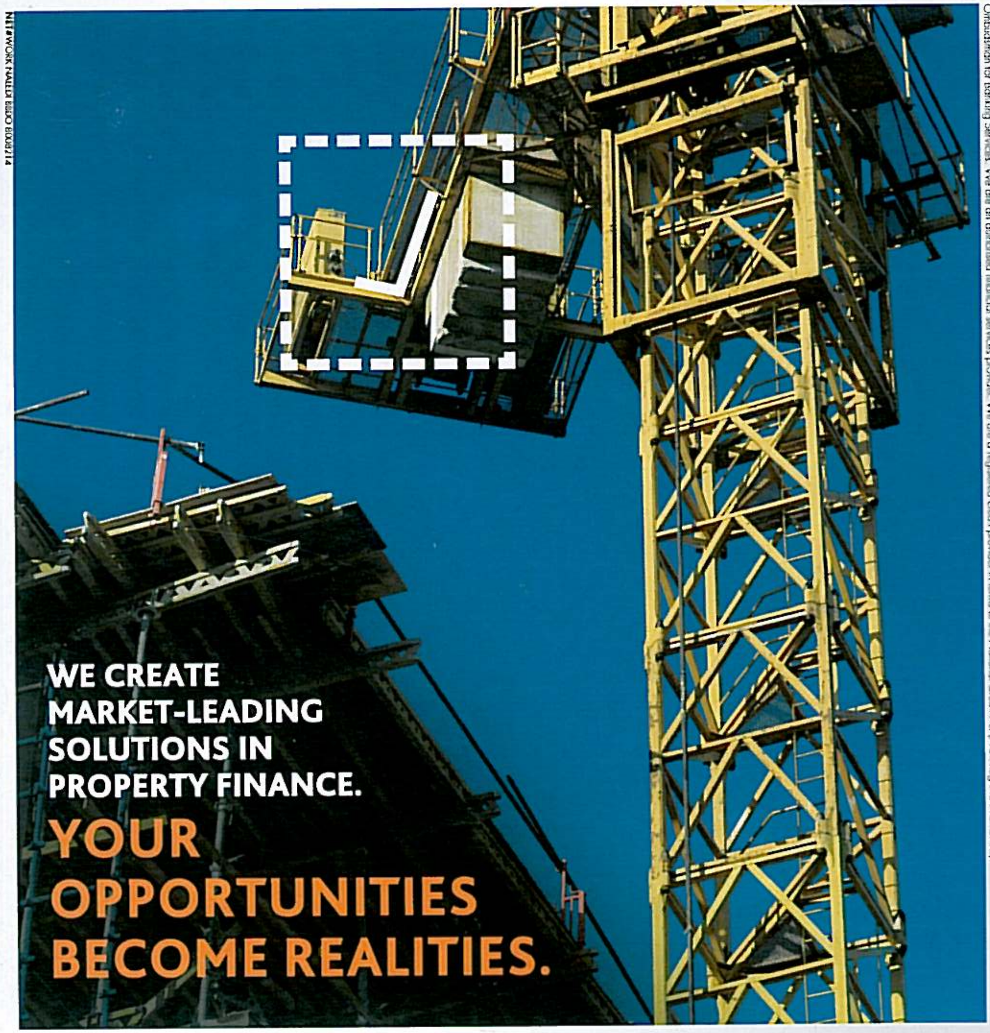

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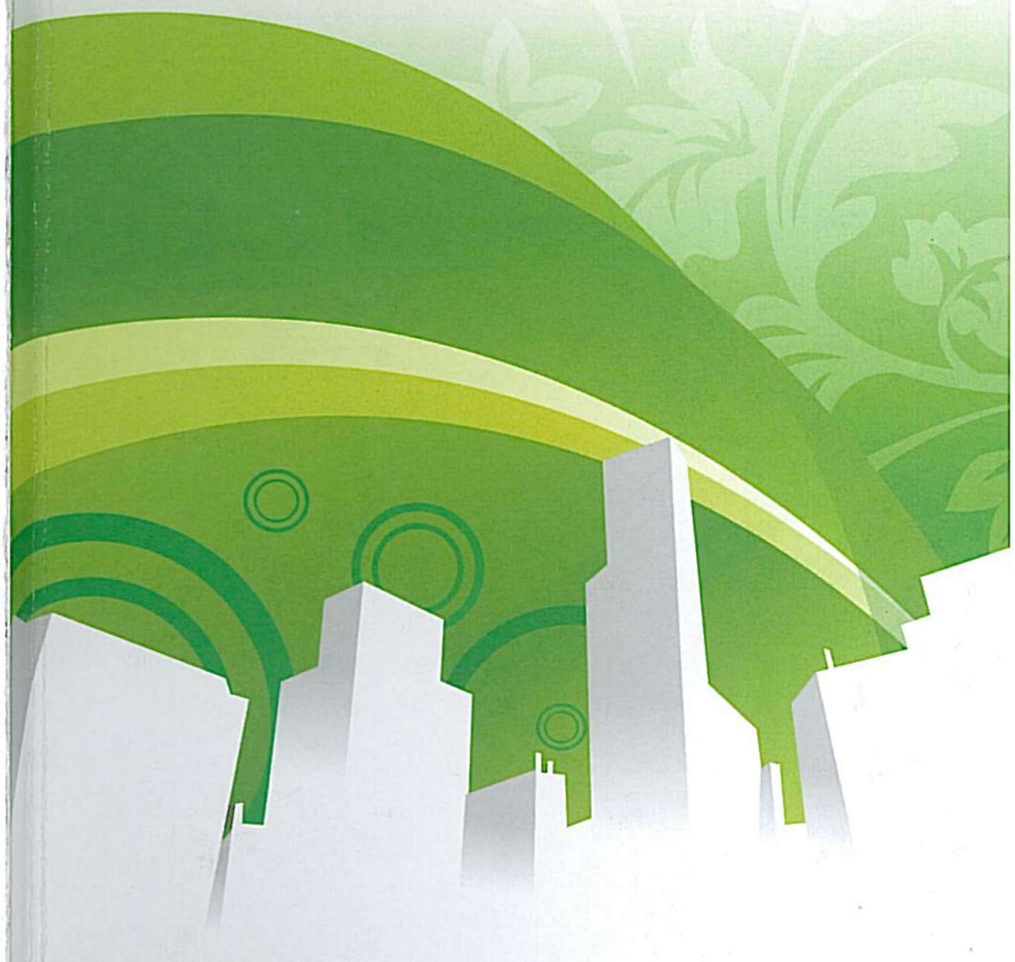
The Green Building Handbook South Africa

The Essential Guide

Volume 2



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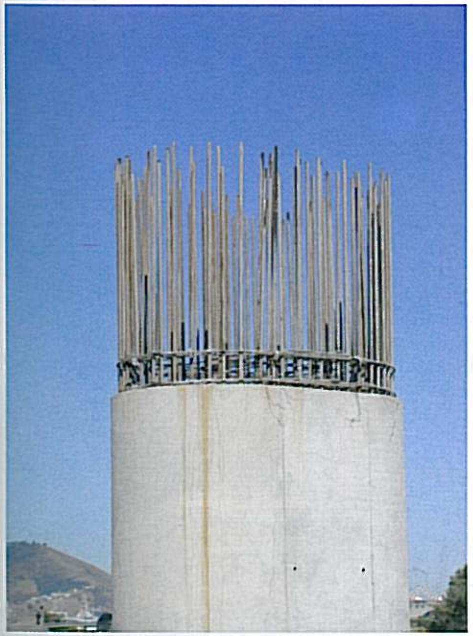

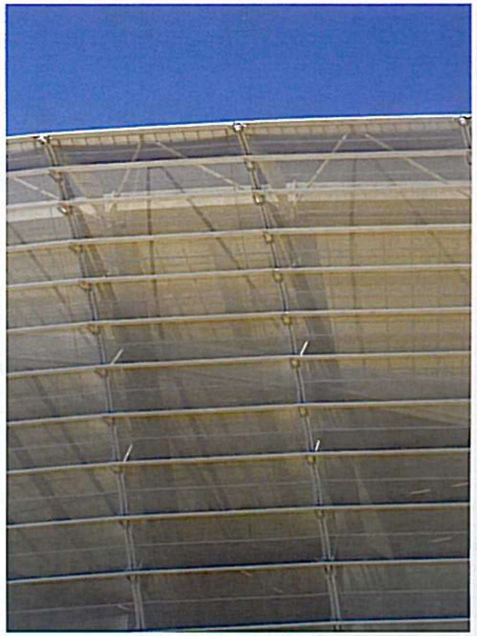

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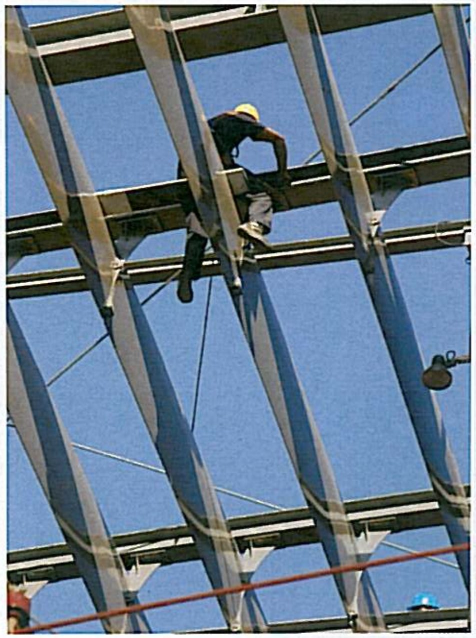

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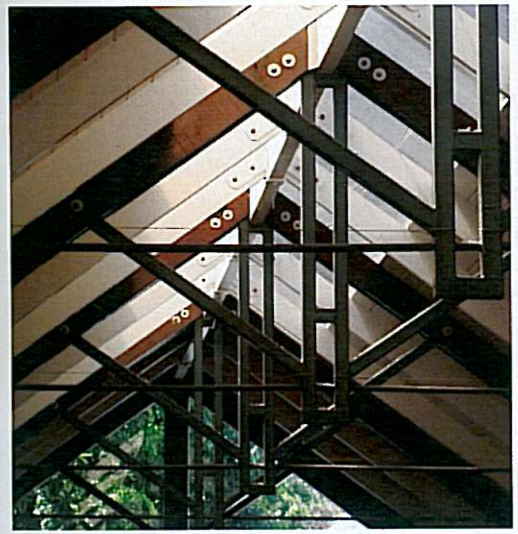

INDOOR ENVIRONMENTAL HEALTH

Dr Sidney A Parsons
CSIR Built Environment

INTRODUCTION

In his book "Green to Green" , David Gottfried, founder of the US Green Building Council (USGBC), reflects on how his "vision to green" started with an initial appreciation that whilse buildings consumed huge amounts of energy, water and wood, poor air in buildings made people sick. He concludes that as most people spend a large percentage of their lives indoors, building-related illnesses and poor indoor air quality resulted in millions of US Dollars of lost productivity.

Indoor Environmental Health (IEH) is a comprehensive term that includes the effects of quantity of air, light and noise in a space and the physical, physiological and psychological aspects from colours, aesthetics, services, outdoor climate and interrelations with the occupants. Appropriate outdoor air rates affect IEH, energy use and the choice of building components including the choice of artificial Heating, Ventilation and Air Conditioning systems (HVAC systems).

The academic strides made to better understand contaminants and their sources, and the improved ability by the scientific community to measure them, tells only part of the story of the effort to maintain safe and comfortable environments. It is often argued that improving IEH is expensive, however, measures can be taken to lower this cost. The appropriate balance between energy efficiency and ventilation for acceptable indoor environmental conditions has become a critical concern for designers and building owners, operators and maintenance personnel worldwide.

Changes in temperature or humidity also have been shown to effect human responses to and perceptions of the chemical content of the air. Multiple laboratory studies have found that subjects describe air as more stuffy, odorous and stale when the air temperature is elevated and the humidity increased, or both. The same mix of chemicals may have fewer impacts on some measured physiological responses at temperatures near the lower end of the "thermal comfort envelope" of ASHRAE Standard 55 than at the higher end .

Fluctuations in the thermal environment could also indirectly affect the quality of the air. The higher temperatures cause increased emissions of volatile organic compounds. Fluctuations may also result in higher air velocity requirements for human comfort (considered an important component of the thermal environment), and can increase evaporation of volatile and semi-volatile chemicals from surfaces and even effect the concentrations of water soluble chemicals or the longevity of biological aerosols. Higher humidity results in higher airborne concentrations of formaldehyde and other highly water soluble substances .

The concern about the health effects associated with exposure to indoor air dates back several hundred years and has increased dramatically in recent decades. Since the energy crisis during the early 1970s, increasing international attention has been focused on indoor air quality. The attention was, in part, the result of the increased reporting by building occupants of complaints about poor health associated with exposure to indoor air. Since then, two types of diseases associated with exposure to indoor air have been identified and labelled, namely, Sick Building Syndrome (SBS) and Building-related Illness (BRI).

SICK BUILDING SYNDROME (SBS)

In the 1970s, building inhabitants complained of discomfort associated with occupancy in non-industrial work environments. These complaints had a temporal character; that is, occupants complained of discomfort while present in the building suspected of causing the symptoms, but symptoms disappeared when outside the building. The phrase Sick Building Syndrome (SBS) was then established.

SBS is characterised by an absence of routine physical signs and clinical laboratory abnormalities. The term nonspecific is sometimes used to imply that the pattern of symptoms reported by afflicted building occupants is not consistent with the pattern of symptoms for a particular disease process. Health complaints by individuals afflicted with the sick building syndrome include mucous membrane irritation (eye, nose and throat), easy recognition of malodours, and symptoms such as headaches, dizziness, difficulty concentrating and fatigue. Additional symptoms can include nose bleeding, chest tightness and feverishness.

Airborne substances that cause increased prevalence of building-related complaints have remained speculative because concentrations of pollutants, other than CO^2 are typically low in buildings with occupants complaining of mucous membrane irritation, headache, lethargy and fatigue.

Studies have shown that complaints have diminished with an increase in fresh air ventilation, and increased with a decrease in fresh air ventilation[7]. Experimental work using biological models have shown that complex mixtures of Volatile Organic Compounds (VOCs) emitted from office products cause irritation in animals. These have been associated with SBS symptoms in chamber studies and have been associated with symptoms in cross-sectional field studies. Solutions include to increase ventilation rates or to install lower emitting products.

BUILDING-RELATED ILLNESS (BRI)

In contrast to symptoms of the SBS, building-related illnesses (BRIs), have a known origin. BRIs have a different set of symptoms and are often accompanied by physical signs and abnormalities that can be clinically identified with laboratory measurements. For example, the hypersensitivity diseases, including hypersensitivity pneumonitis, asthma and allergic rhinitis are caused by individual sensitisation to bio-aerosols. Microorganisms which are incapable of reproducing outside a living animal cell are obligate

intracellular parasites and include viruses and bacterium. Each of these types of microorganisms is capable of causing airborne infectious disease in humans and are transmitted by aerosol; the H1N1 virus, for example, can be transmitted by the airborne route via droplet dispersion.

Nearly all viral and a few bacterial diseases that are present in indoor air are transmitted from human to human. Therefore, each infected individual (or human host) behaves as a reservoir, amplifier and disseminator. Typically, dissemination involves coughing or sneezing, both of which have been documented to add infective organisms to the air. These dissemination methods produce aerosols of large droplets that evaporate rapidly, resulting in small droplets (droplet nuclei), which can remain airborne for long periods and are capable of penetrating the human lower respiratory tract. Once in the air, the virus or bacteria-containing particles spread throughout the space and become diluted by incoming air and the organisms begin to die[11].

Transmission of airborne disease from a human source rarely occurs outdoors because the quantity of air is much larger than the quantity of the contagion[10]. However, in indoor environments, particularly in confined spaces with low ventilation rates or with highly infectious agents, infective organisms can accumulate to infectious doses. The airborne amounts depend on the concentration of the organism in respiratory secretions, the coughing and sneezing rate of the infected hosts, the number of hosts in the space and the building ventilation rate[10].

M. tuberculosis (TB), as a airborne human-source disease, is a highly contagious disease which occurs after a first infection. South Africa has a high and increasing burden of Tuberculosis, with the high prevalence of both drug-susceptible and drug-resistant strains. The emergence of drug-resistant strains of the disease has exacerbated the situation through posing a serious risk to public health. Drug-resistant strains, multi drug-resistant (MDR) and extensively drug resistant (XDR) TB strains can be acquired directly: MDR and XDR-TB are not necessarily acquired through defaulting on medication prescribed for drugs-susceptible strains of the disease.

The immuno-compromised individuals who are HIV positive or have Aids are at greatest risk for TB exposure. The increase in incidence in recent years has prompted renewed interest in the study of TB and its relationship to transmission in indoor air, especially where people with undiagnosed, untreated and potentially contagious TB are frequenting public and general commercial settings. Findings from recent studies concluded that one of the major problems in controlling the transmission of TB occurred as a result of building design and inadequate maintenance thereof.

DILUTION VENTILATION

When considering the essential environmental control necessary to minimise risk of indoor exposure to airborne micro-organisms, the term "dilution ventilation" is used to describe natural or mechanical contaminant control systems. "Dilution systems" lower the concentration of contaminants by mixing contaminated air with fresh air but never reduce or eliminate the total amount of contaminants released.

A standard model of airborne infection usually referred to as the Wells-Riley equation, is useful for understanding the relationship between the number of new infections, (C) and the number of susceptibles (S) and infectors (I) occupying a defined space, the number of doses of airborne infection (q) added to the air per unit time by a case in the infectious stage, the pulmonary ventilation per susceptible (p) in volume per unit time, the exposure time (t) and the volume of fresh or disinfected air into which the quanta are distributed (Q):

C=S(1 E -IQPT/Q)

In this equation, the exponent represents the degree of exposure to infection and is the probability of a single susceptible being infected. The parameter (q) is derived from the term quantum which Wells used to indicate an infectious dose, whether it contains a single organism or several organisms[13]. The Wells-Riley Equation is useful for understanding the impact of air dilution by increasing the volume of fresh or disinfected air on airborne infection. Increasing (Q) decreases exposure by diluting air containing infectious particles with infectious particle-free air.

The degree to which the air is conditioned is a function of the climate, the season and the required space temperatures. The time of day affects the energy cost paid by the building owner to condition the increased outdoor air.

Many standards have been developed to aid the designer or building owner / developer in avoiding IEH problems. The two most used and referenced standards are from the ASHRAE and are:

- ASHRAE Standard 62-1989, Ventilation for acceptable Indoor Air Quality.
- ASHRAE Standard 55-1992, Thermal Environmental Conditions for Human Occupancy.

The following South African Legislation and supportive Regulations also provide designers or building owner / developer guidance:

- SA Building Regulations and Building Standards Act No. 103 of 1977, as amended.
- SABS 0400:1990, Code of practice for the application of the National Building Regulations (soon to be replaced by SANS 10400 which is presently under review).
- The Occupational Health and Safety Act 85 of 1993, as amended.
- Government notice R1390 of 27 December 2001 [Hazardous Biological Agents Regulations] as promulgated under section 43 of the Occupational Health and Safety Act of 1993.

These documents prescribe quantities of outdoor air and temperature and humidity levels which are based upon laboratory research and field measurements. They have all been developed using a consensus process from experts in the fields of IEQ (i.e. with respect to both SBS and BRI).

ACHIEVING AN APPROPRIATE BALANCE BETWEEN IEH AND ENERGY CONSUMPTION

By improving ventilation effectiveness, the indoor air quality will be enhanced significantly without the need for excessive quantities of outside ventilation air, thereby avoiding the higher capital and operating costs and least of all increased energy consumption. The primary reason for ventilation as discussed above is to supply clean air to the space and extract contaminants as efficiently as possible. The measure of this is the ventilation effectiveness. This effectiveness can be applied in two ways:

1. When the positions of the contaminant sources are known, the design of the ventilation system should aim at removing the contaminants locally, i.e. from where they are produced avoiding further spread. This focus is on what is termed "Contaminant removal effectiveness". This determines the effectiveness of the ventilation to remove the identified contaminants.
2. At the design stage of the system, when the ultimate use of the space is unknown, the ventilation installation should be designed to give a rapid air exchange in the room. The "Air change efficiency" is a measure of this.

It is recommended that only in the case where the contaminant source is known, should the focus be on "Contaminant removal effectiveness", in all cases the objective should be to exchange the air as quickly as possible, and so the design focus should be on the "air change efficiency" measure.

To properly apply all the above, however, knowledge of building system types and their inherent pros and cons in relation to IEH is beneficial. In general, central systems maintain better IEH than distributed air systems that utilise unitary equipment, due to the lack of outdoor air traditionally found in distributed systems. There are opportunities among the various system options to economically provide the required outdoor air requirements to meet these standards for IEH. These include:

- Thermal energy storage systems
- Cold air distribution systems
- Water loop heat pump systems with separate outdoor air conditioning systems
- Single and dual-path dehumidification technologies
- Heat recovery technologies
- Demand ventilation control
- Filtration

CONCLUSIONS

Several studies have attempted to determine the correlation between increasing the amount of outdoor air used and the cost of energy and first cost of HVAC systems. Uncontrolled or excessive quantities of outside ventilation air to control indoor airborne contaminants will increase cooling and heating costs, so energy efficient buildings must be designed and operated to introduce no more than the necessary amount of outside air. Using advances in technology can significantly reduce, or in some cases, eliminate any increase in energy usage even when meeting the required amounts of outside air. Significant savings can also be obtained through operation and maintenance programs specifically designed to avoid IEH problems and reduce operating costs.

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However, it should be emphasised that the most cost-effective tool in reducing energy costs is to implement a comprehensive operation and maintenance programme. All HVAC systems require certain levels of maintenance on a periodic basis for effective operation. A high level of maintenance will elevate the performance of a HVAC and thus assist in complying with ASHRAE Standard 62-1989.

Maintenance tasks should also be designed with an IEH focus. If properly administered, a comprehensive maintenance programme will detect many system problems before they become IEH problems. For example, a dripping pipe may allow mould to grow. If one of the tasks of the maintenance programme is to visually inspect the pipe work on a periodic basis, the leak would be found and the problem prevented.

Whilse even a comprehensive maintenance programme will not discover all system problems before they become IEH problems, any comprehensive programme will assist in dealing with IEH problems quickly and effectively. In addition to the IEH benefits, a comprehensive maintenance programme can also reduce energy use.

REFERENCES

David Gottfried. Green to Green – the transformation of an industry and a life. Worldbuild Publishers, 2004. ISBN 0-9744326-0-1
Berglund and Cain,1989
ANSI/ASHRAE Standard 55-1992, "Thermal Environmental Conditions for Human Occupancy" Atlanta: American Society for Heating, Refrigeration and Air Conditioning Engineers Inc.
Molhave et al. IA Journal
Mathews, 1980.
Burge, S., Hedge, A. & Wilson, S., et al., 1987. Sick building syndrome: a study of 4 373 office workers. Annual Occupational Hygiene, 31:493–504.
Kreiss, K. & Hodgson, M.J., 1984. Building-associated epidemics. In: Indoor Air Quality, Walsh, P.J., Dudney, C.S. & Copenhaver, E.D. (eds), Boca Raton, FL: CRC Press/Lewis Publishers. pp. 87–108.
Robertson, A.S. & Burge, P.S., 1985. Building Sickness. Practitioner, 229:531–534.
Sarnet, J.M., Marbury, M.C. & Spengler, J.D., 1988. Health effects and sources of indoor air pollution. Part II. Am. Rev. Respir. Dis., 137:221–242.
Couch, R.B., 1981. Viruses and indoor air pollution. Bull. NY Acad. Med., 57:907–921
Lowenstein, H., et al., 1979. Airborne allergens – identification of problems and the influence of temperature, humidity and ventilation. In: Proceedings of the First International Indoor Climate Symposium, Danish Building Research Institute, Copenhagen, pp. 111–125
Riley, R.L., 1982. Indoor airborne infection. Environ. Int. 8:317–320
Wells, W.F. (1955). Airborne Contagion and Air Hygiene. Cambridge, Mass.: Cambridge University Press, p. 5, 117–122, 329.
E Mundt, H M Mathisen, P V Nielsen & A Moser. Ventilation Effectiveness. REHVA Guidebook (No 2), 2004. ISBN 2-9600468-0-3