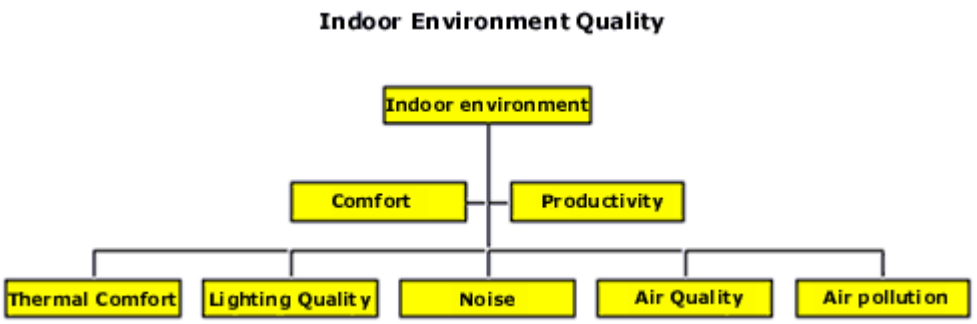
Indoor Environmental Quality

The primary objective of a building is to provide an environment that sustains the activities carried out within. City dwellers spent most of their time inside buildings, in homes, places of leisure and workplaces. For a quality lifestyle, safe, healthy and comfortable indoor environments are needed. There is a relationship between productivity, space comfort, indoor air quality and occupant satisfaction, which optimises energy use, owner needs and employee evaluation of workspace conditions.

When occupants are exposed to an environment that results in discomfort or illness, unnecessary costs may be incurred through absenteeism or loss of productivity. Investments in improving the quality of design, construction and maintenance of buildings which result in only decreased absenteeism or increased productivity, are highly cost-effective. Comfort conditions can be quantified in terms of air temperature and movement, relative humidity, lighting quality, noise, etc.



Indoor air quality may be defined in terms of 'freshness', usually defined by carbon dioxide level, and by 'purity', i.e., acceptable levels of annoying or harmful pollutants. Still or stale air may be discomforting, but the health impacts of polluted air can be more serious, from irritation, temporary debilitation to severe illness.

Pollution indoors can arise from outdoors, through outside air intakes and from uncontrolled infiltration. Congested streets, industrial effluent, construction sites, etc., contribute to the pollution of local ambient air. High traffic densities and vehicular access into buildings introduce an array of pollutants the potency of which is of increasing concern. Air duct linings, dirty air handling equipment, etc., contaminate during the conditioning and transport of air. Internal sources of pollutants are people, smoking, equipment, furniture, finishes, etc.

Interior lighting has a significant impact on the quality of the indoor environment affecting occupant comfort and productivity. However, as discussed in the section on Electrical Services, the design of lighting systems needs to embrace energy efficiency and power quality issues also.

Noise and vibration have substantial impact on humans and their control is indispensable in the establishment up of a comfortable indoor environment. Inside a building, noise and vibration problems come mainly from the air conditioning systems, human activities, mechanical services and the break-in noise from outdoors.

Research Focus

The Department research focuses on evaluating the environmental conditions found inside buildings. The Department recently completed a large scale in-office stud covering the measurement of thermal comfort, indoor air quality, noise and lighting. The extensive database obtained is useful in determining the optimum design criteria for indoor environments. Several prototypes for logging indoor environmental parameters have been developed. These can monitor continuously the physical environment and subjective responses of occupants.

The work continues with measurement of ventilation system performance. A measurement methodology for evaluating ventilation performance in large office spaces has been developed based on monitoring metabolic carbon dioxide, tracer gas decay and air flow measurements. Studies on indoor air pollution targets those pollutants which are of most concern locally: radon, biological, carbon monoxide, and volatile organic compounds.

The noise and lighting surveys reveal very useful information for enhancing the design of open plan offices. Research on noise control, standard testing of sound power, sound absorption, flow noise and office noise characteristics are in progress.

Specialist Facilities

An Indoor Environmental Laboratory was set up in 1993 with a large grant from the Research Grants Council. The test rigs in this laboratory are mostly portable, comprising various gas analysers, temperature, humidity and air flow sensors, etc., for measurements in occupied spaces, on air-side systems, etc.. Test rigs have been developed for the evaluation of thermal comfort, indoor air quality and ventilation performance. These include:

- thermal comfort carts consisting of a data logger, carbon dioxide monitor, sensors for humidity, air temperature, globe temperature and air speed at heights of 0.1m , 0.6m and 1.1m, to comply with ASHRAE 55-1992. These are used in conjunction with an occupant questionnaire to evaluate the acceptability of the indoor environment;
- a toxic gas measurement set for the common toxic gases, as well as temperature, RH and dust;
- air flow test rig for the evaluation of air flow in air-conditioned spaces by a flow visualisation technique;
- a high precision gas analyser is used for tracer gas measurements. A sampler/doser gas multiplexer has been developed for measurement in large volume spaces such as open-plan offices;
- the environment inside air ducts can be evaluated using dust monitors. A mechanical robot with built-in camera is available to conduct visual inspections;
- volatile organic compounds can be measured by photo-acoustic spectroscopy or gas chromatography;
- an air-tight stainless steel chamber (2 x 2 x 1.6m3) has been built for material and equipment emission and air cleaning testing;
- micro-organism sampling has been done by CFU counts on agar plates by the impact method, or CFU in air flows by dynamic sampling on agar strips.

Setting up sophisticated air quality monitoring systems in the Department's Indoor Air Quality Laboratory

The Acoustics Laboratory is equipped with a wide range of acoustics equipment suitable for noise and vibration measurements inside and outside buildings, on HVAC systems and equipment, such as:

- measurment of noise or vibration levels, with weighting or frequency analysis;
- monitoring of noise level, with statistical noise level measurement;
- sound power by comparison method and sound intensity method;
- normal incidence sound absorption coefficient and sound impedance by standing wave tube method;
- reverberation time of a room;
- impact sound transmission in buildings;
- determination of coherence and cross-correlation of two signals to see the cause and effect relationships;
- assessment of hearing loss for auditory health monitoring;
- duct break-out noise measurements.

Current Projects

- A Study on the Active Control of Noise that Breaks Into Buildings. Tang, S. K., Li, X. D. (R Assoc) and Leung, C. K. (RA)
- Active Control of Sound Transmission into Enclosures Through Panel Structures. Tang, S. K. and Tian, J. (Chinese Academy of Sciences)
- Air Recirculation Systems of Building in Hong Kong. Yik, F. W. H., Chau, C. K., Burnett, J. and Law, A. K. Y. (FT MPhil)
- An Integrated Disciplinary Solution to Indoor Air Quality. Jones, P. (UWCC), Burnett, J., Chan, D. W. T. (PT PhD).

- Building Environment Performance Model for Variable Air Volume Systems in Air-conditioned High Rise Buildings in Sub-tropical Climate Zone. Burnett, J., Chan, D. W. T. (PT PhD) and Mui, H. K. W. (FT MPhil)
- Evaluation of Volatile Organic Compound During and After Building Renovation. Niu, J. L., Burnett, J., Chao, C. Y. H. (HKUST) and Chui, W. Y. (FT MPhil)
- Indoor-Outdoor Relationships for Airborne Particulate in Residential Building, Burnett, J., Chao, C. Y. H. (HKUST) and Tung, C. W. (FT PhD)
- Low Frequency Sound Transmission Through Asymmetrical Rectangular Air Duct. Tang, S. K. and Chow, K.K. (RA)
- Noise Generation Inside Air Duct due to Turbulent Flow. Tang, S. K. and Ffowcs, J. E. (Unviersity of Cambridge)
- Optimised Design of Car Parks Ventilation Systems. Burnett, J., Deng, S. M. and Chan, J. M. Y. (PT PhD)
- Performance Indicators for the Quality of the Environment Within Air-conditioned Offices. Burnett, J., Chan, D. W. T. (PT PhD), Chung, T. M., Tang, S. K., Ng, S. C. H. and Liu, F. X. (RA)
- Study of Existence, Distribution and Survival of Airborne Legionella in Indoor Environments by Polymerase Chain Reaction Method. Chan, D. W. T, Burnett, J. and Zhou, S. (R Assoc)
- The Development of Noise Criterion for Air-conditioned Office Buildings. Tang, S. K. and Leung, C. K. (PT RS)
- Time budget Survey of the Hong Kong Population and Measurement of Total Exposure to Major Air Pollutants. Niu, J. L., Burnett, J., Chao, C. Y. H. (HKUST) and Tu, E. Y. (PhD)
- Ventilation Performance in Large Air-conditioned Office Building. Burnett, J., Jones, P. (UWCC)

Students testing the acoustical properties of a sound insulated booth

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