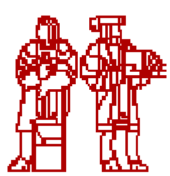
GRADUATE STUDIES IN BUILDING TECHNOLOGY

AN INTERDISCIPLINARY PROGRAM INCLUDING

- **DEPARTMENT OF ARCHITECTURE (Home Department)**
- **DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING**
- **DEPARTMENT OF MECHANICAL ENGINEERING**



Revised on December 10, 2002

❐ CONCEPT OF THE PROGRAM

The graduate program in Building Technology is an interdepartmental program which brings together the faculty and students from the Departments of Architecture, Civil and Environmental Engineering and Mechanical Engineering. The program is open to qualified students with a suitable background in technology or with a degree in engineering, science, or architecture. This is a research based program that provides a focus for graduate students interested in the development and application of advanced technology for buildings of all types. Students in this program take subjects in basic engineering disciplines along with subjects that engage the application of these topics to buildings. The interdepartmental degrees, Master of Science in Building Technology and Ph.D. in Building Technology, are awarded by the program.

❐ IMPORTANCE OF BUILDING TECHNOLOGY

The building industry represents one of the largest, and most important, enterprises in world. Some of the statistics for the US alone are quite staggering: roughly one quarter of the assets of large corporations are tied up in buildings and land; costs associated with housing are the largest single expenditure of an average family; about one third of all investment in the U.S. is for the construction of commercial and residential buildings; and new housing construction costs represent about eight percent of the annual GNP. The average American family constantly confronts problems of home affordability while shortages of minimally acceptable housing for lower income families continue to grow. One third of the U.S. energy consumption is used in residential and commercial buildings and the percentage is growing relative to other sectors. For fast-growing economies in other parts of the world, there is a growing demand for practical, sustainable building designs that will provide a higher standard of living with minimal resource demand.

Many of these problems are being met both in the U.S. and internationally by innovations in building technology. These innovations, for example, apply recent advances in the fields of materials, manufacturing and thermosciences to the construction of new buildings, to the retrofit or rehabilitation of existing buildings and to the efficient operation of buildings. Graduates of the Building Technology program meet the need for a new generation of trained professionals in the building field who understand the technological fundamentals as well as the broader architectural design and construction processes. Likely careers of graduates are in the building materials industry, in building construction and industrialized buildings, as well as practice with architect-engineers, energy-efficiency consultants, and service within government and regulatory agencies related to housing and buildings.

❐ RESEARCH

Research is the cornerstone of the program. Thus, each student admitted to the program is expected to take part in a research project. A major contribution to the student's education in this program comes from the experience gained carrying out research and design on the fundamentals of new technologies and their application to buildings. The research project will normally be on a subject under current investigation by an interdepartmental team of faculty and students or by an individual faculty member. This research is typically used by a student to fulfill the thesis requirement for the degree. The sponsored research gives the students exposure to both practitioners and other international scholars working with important issues in their field of interest. Many students serve as research assistants, receiving financial support to cover tuition and some living expenses.

Research projects range from experiments in specialized laboratories within the three departments to analysis, computer applications and design. Areas of current research include:

- ☞ Building Control and Diagnostics
- ☞ Building Energy Studies
- ☞ Building Materials
- ☞ Computer Graphics for Physical Performance
- ☞ Indoor Air Quality, Building Ventilation, and Building Environment Modeling
- ☞ Sustainable Building Design

Current and recently completed projects are describe below:

♦ <u>Building Controls and Diagnostics</u>

• VENTILATION CONTROL STRATEGIES Building space-conditioning systems often perform at poor part-load efficiencies because there is limited information feedback from individual offices and because part-load operation has led to large throttling losses. The increased use of microelectronics and power electronics in building control systems offers two benefits for ventilation systems: first, fans can be controlled not by adjusting dampers that throttle flow but by regulating the speed of the motor; and second, by communicating with digital rather than analog flow-regulation dampers in each occupied space, the central fan can be slowed to the speed that minimizes pressure drops across these dampers. A recently completed program tested and analyzed both of these benefits, with the goal of quantifying energy savings and providing to building owners, control manufacturers and electric utilities the information needed to make informed decisions about investing in new technologies. The performance of ventilation systems was monitored in several buildings and models were developed to correlate fan power with airflow and pressure.

Principal investigator: Les Norford
Sponsors: MIT Physical Plant, Northeast Utilities and Empire State Electric Energy Research Corporation.

• ELECTRIC METERING AND DIAGNOSTICS Common electric meters are well developed electromechanical devices with little or no intelligence. The electric utility industry requires extensive load survey data to plan for future power generation needs and to prove the efficacy of utility-supported conservation programs. Customers would benefit from the same data, to assess energy usage and to detect and diagnose equipment faults. The Building Technology Program has joined the Laboratory for Electromagnetic and Electronic Systems at MIT to design and develop a meter that can separate loads from measurements made at a single point within a commercial building, to reduce or eliminate the need for expensive submetering of individual pieces of equipment.

Principal investigators: Les Norford, Steven Leeb, and James Kirtley
Sponsor: Electric Power Research Institute, Empire State Electric Energy Research Corporation and Johnson Controls

• SIMULATION OF HVAC SYSTEM PERFORMANCE Heating, ventilating, and air-conditioning (HVAC) systems are often poorly controlled. Engineers have not been able to rapidly prototype HVAC systems, in simulation, and assess the performance of existing or innovative control systems, including interactions between individual feedback control loops. MIT and Loughborough University, UK, have joined forces to develop a simulation test-bed for the development and analysis of control systems for a large class of HVAC systems.

Principal investigators: Les Norford and Philip Haves (Loughborough University, U.K.)
Sponsor: American Society of Heating, Refrigerating and Air-Conditioning Engineers

♦ **Building Energy Studies**

• INTERNATIONAL STUDIES Building Technology faculty and students have teamed with Architectural Design faculty and students to improve housing and institutional buildings in Pakistan and India, an effort initiated by the Aga Khan Program in Islamic Architecture. Work includes studies of the benefits of thermal insulation, structural analyses to determine needed seismic reinforcing, and design and construction of new or renovated housing and schools. MIT is also taking a leading role in developing a new generation of building energy codes for Russia, a project that has included work with regional authorities and with the construction industry, to identify cost-effective improvements in the building construction and heating systems.

Principal investigator: Les Norford
Sponsors: Aga Khan Program, MIT HASS Fund, and U.S. Environmental Protection Agency

• ENERGY CONSERVATION IN OFFICE EQUIPMENT AND LIGHTING A series of studies evaluated the impact of office electronics on building energy. Work included estimates of market growth and aggregated impact on the electric power system, a technical assessment of opportunities for reduced energy usage, development of test procedures to provide standard measures of equipment energy consumption, and measurements of new equipment that includes power-management features. For lighting, a separate project is evaluating systems for distributing light through buildings with fiber optics or light guides. This system offers the possibility of stripping the heat from large, centralized lamp banks to reduce air-conditioning loads.

Principal investigator: Les Norford
Sponsor: U.S. Environmental Protection Agency, Lawrence Berkeley National Laboratory, and the American Council for an Energy-Efficient Economy

♦ Building Materials and Construction

• COMPOSITE MATERIALS FOR BUILDING ENVELOPES Traditionally the envelopes of houses are site-assembled from basic components with separate materials serving as the structural members, the weather shield, and the thermal insulation. In this recently completed project composite materials were developed that combined these separate functions. In addition, a construction system well suited to automated fabrication and simple field assembly is being developed. A proof-of-concept roof system, the first product of this research, is based on innovative design and analysis strategies and is compatible with conventional systems while minimizing house-specific design. The roof components include thin-ribbed stress-skin panels, a multi-function ridgebeam and a spline-connection scheme.

Principal investigators: Leon Glicksman, Leonard Morse-Fortier, Lorna Gibson, and John S. Crowley
Sponsors: Alcan International Ltd., Dow Chemical USA, GAF Corp., Hoechst-Celanese, Macmillan Bloedel Ltd., Miles Chemical Corp., USG Corp., Certaineed Corp., GE Plastics and Weyerhauser Co.

• ADVANCED THERMAL INSULATIONS New buildings and renovated existing buildings, as well as appliances, can be made more energy efficient by the use of insulations which are more compact for the same level of performance. Recently completed research on closed-cell foam insulation improved its insulating performance and at the same time allowed it to be manufactured with elements which are not hazardous to the environment (in particular which do not deplete the ozone layer). Advanced insulation, which includes a composite of foam and vacuum technology, was also developed.

Principal investigator: Leon Glicksman
Sponsor: U.S. Department of Energy

• THERMAL INSULATION FOR DEVELOPING COUNTRIES In a number of resource-poor developing countries, buildings are constructed of masonry material without thermal insulation. In winter, these buildings are uncomfortably cold or even uninhabitable. MIT is developing a low- cost thermal insulation for such countries. The feedstock for the prototype insulation is straw, a by-product of wheat threshing. The investigations have focused on straw density, the type and amount of binder needed to make straw panels, thermal and structural tests, and means of attaching the panels to stone walls and applying a surface finish. MIT students have made on-site surveys and prototype tests in Pakistan.

Principal investigators: Leon Glicksman and Les Norford
Sponsors: ICI Polyurethanes and American Society of Heating, Refrigerating and Air-Conditioning Engineers

• IDENTIFICATION AND PROMOTION OF LOCALLY SUSTAINABLE BUILDING CONSTRUCTION METHODS FOR LATTER-STAGE SLUM IMPROVEMENT. Slum-improvement strategies are a result of conclusions drawn from the most successful projects that have addressed city-center squatter communities. While the factors that need to preside in successfully addressing the needs of the residents of these settlements are complex and necessarily mutable depending on location and overall purpose of the project, it has been recognized by a wide range of organizations that the upgrading, as opposed to physical removal, of slums is a better long-term solution. The creation of mechanisms, financial, political and institutional, that provide a well-conceived 'package' of service infrastructure and the establishment of land tenure are the most important first steps in alleviating the health risks and economic hardships that the residents endure. Later, the sustainability of these improvements should lead to an increased desire to upgrade the physical quality of the dwelling units themselves. This project proposes the identification of locally sustainable methods of construction for dwelling upgrade as a strategy for catalyzing the development of viable income producing activities within and adjacent to the confines of the slum itself. This promotion is in the service of establishing a sustainable process of continual slum-improvement after the work of this project has been completed. The identification of construction methods and the consideration of innovative materials and assembly systems will contribute to a realistic proposal for a set of building components to be used in the upgrade of dwelling units. The location of the project is to be determined.

Principal Investigator: John E. Fernandez
Sponsor: 3M Innovation Award

• CENTER FOR SUSTAINABLE MATERIALS AND BUILDING ENVELOPES The study of sustainable materials necessarily involves an extremely large set of scientific and economic criteria to reasonably establish a productive comparative analysis. While a number of systems have been proposed and developed, none has secured a clearly predominant position over all others. Therefore, it is necessary to glean from a great number of sources the necessary information and rating criteria to offer a current and productive assessment of the state of rating materials for their sustainable value. This proposal offers to study the available literature and tools for determining the sustainability of construction materials for the purpose of:

1. establishing the state of the art of ratings systems and their attendant criteria,
2. identifying the most recent and important innovations in sustainable material technologies, and identifying key areas for further research.

Principal Investigator: John E. Fernandez
Sponsor: Department of Energy

• THREE-DIMENSIONAL FIBER TEXTILE COMPOSITES FOR USE IN CONSTRUCTION. Three dimensional fiber composites have resulted from a search for viable alternatives to 2D composite laminates. As a result of increasing concern regarding the difficulty with which 2D composites have been able to address delamination from impact, in-plane shear stresses and transfer of axial and bending stresses between adjacent composite elements, 3D fiber textile composites (FTCs) have recently received greater attention. For many reasons, the industrial application of 3D FTCs has lagged far behind the use of 2D composites in high-performance industries such as aerospace and large-scale marine structures. However, several isolated yet noteworthy applications have been implemented in less demanding performance scenarios for civil and architectural structures. The lower level of performance requirements makes the use of 3D FTCs a possible way in which to lighten and strengthen typical structural and non-structural components used in civil and architectural structures. In addition it is possible that 3D FTCs may provide a versatile medium for the inclusion of specialized fibers for a variety of enhanced properties. One particularly interesting possibility arises from the inclusion of "smart" or "responsive" fibers within the architecture of the 3D FTC.

Principal Investigator: John E. Fernandez

• NATURAL FIBER REINFORCEMENT OF LARGE-SCALE COMPOSITE POLYMER PANELS Recently, natural fibers (NF) have been investigated as filler materials capable of serving as localized tensile reinforcement and volume fillers within several types of polymer matrices. A number of natural fibers have been under continued investigation for use in natural fiber reinforced polymer composites (NFRC); including wood fiber, jute, sisal, kenaf, flax, wheat straw and bamboo. These fibers have been coupled in a matrix primarily composed of two commodity plastic matrix materials: polyethylene (PE) and polysytyrene (PS). While specific mechanical properties of natural fibers vary according to the particular fiber, the overall performance of natural fibers lies within a relatively tight range as a result of similar molecular composition. An increasing amount of interest has developed over the past few years for NFRCs because of their ease of production, subsequent increase in productivity, cost reduction, lower density and weight and use of renewable resources. The automobile industry has begun to apply NFRCs in a variety of exterior and interior panel applications. The significant weight savings and the ease and low cost of the raw constituent materials have made NFRCs an attractive alternative material to glass and carbon fiber reinforced polymer composites. However, further research needs to address significant material and production obstacles before commercially available NFRCs are widely used in architectural and civil works.

Principal Investigator: John E. Fernandez

• FIBER REINFORCEMENT OF A COMPOSITE EXTERIOR WALL PANEL FOR THE PURPOSE OF RESISTING HIGH-VELOCITY IMPACT EVENTS The introduction of fiber reinforcing into the exterior finish component of an exterior wall assembly may aid in preventing catastrophic failure of the integrity of the wall during events in which high-velocity impact is likely. The most important events to address are those conditions caused by naturally occurring high winds and blast events. During these events, it has been observed that a wide range of objects become lethal projectiles that pose significant hazards to both personal injury and property damage. While layered polymer composites have demonstrated an increasing level of resistance to projectile impact, significant difficulties remain that require further research. In particular, delamination from low and high velocity impact has been a major problem that threatens the structural integrity of the panel. The use of composites for exterior sheathing is a growing area for research and architectural and civil applications in the US, and especially in Europe and Japan. For the advancement of the use of large-scale composite panels for exterior sheathing, further research regarding resistance to impact should be undertaken.

Principal Investigator: John E. Fernandez

• SELF-HEALING SMART FIBER INCLUSION INTO AN AIR/VAPOR BARRIER TEXTILE SUBSTRATE MATERIAL Self healing fibers have received a significant level of interest primarily with applications for inclusion in reinforced concrete as a crack management strategy. These "smart fibers" have been added as discrete elements within the concrete matrix. The self-healing fibers are primarily fluid-filled hollow capillaries that contain a bonding agent that, when released, slow or prevent the spread of a crack through the concrete matrix. Self-healing fibers have also been proposed as a strategy for addressing debonding events between the concrete matrix and reinforcing bars. Another application is proposed for this type of smart fiber. The management of the transfer of heat through an exterior wall is an important aspect of the thermal performance of that envelope; one that is substantially compromised by air infiltration and exfiltration. Standard building practice, especially in residential construction, usually requires that a membrane be applied to the building volume to reduce the movement of air between the interior and exterior. Any discontinuities in this membrane may allow for the passage of air to and from the exterior. Self-healing fibers, as an inclusion within the weave of an air/vapor barrier textile, will be studied as a strategy for passively sealing the miscellaneous discontinuities that arise during the application and lifetime of the membrane.

Principal Investigator: John E. Fernandez

• INCORPORATION OF A SMART FIBER NETWORK WITHIN A 3D FIBER TEXTILE COMPOSITE NEAR-NET PREFORM STRUCTURAL MEMBER FOR REMOTE STRUCTURAL MONITORING 3D fiber textile composites are a type of fiber architecture that allows for the inclusion of a variety of fiber types within a three-dimensional near-net preform network. The inclusion of monitoring "smart fibers" within the architecture of the woven material allows for the through-member permeation of a fibrous sensor material. Typical fiber materials used for stress and strain monitoring are optical glass fibers linked to a central processor. In this way it is possible to gather important information regarding the health of a structure during construction and during its lifetime from a remote location. The study proposes to evaluate fibers for inclusion within a 3D FTC structural member as well as propose various sensor network architectures most productive for the applications listed. The materials chosen need to conform to the stresses inherent in the pultrusion and weaving processes during the production of the standardized structural forms.

Principal Investigator: John E. Fernandez

♦ **<u>Computer Graphics for Physical Performance</u>**

• VISUALIZATION OF LIGHT AND SOUND Recent advances in computer graphics hardware and techniques have made it possible to visually render and explore geometrically-modeled settings in real time or at interactive rates. Computer simulations can generate significant spatial and temporal data describing three-dimensional environments. Computer graphics visualization techniques provide the means to display this multidimensional data, allowing substantial amounts of information to be communicated to the designer. This research concerns the development of simulation techniques to improve the accuracy of lighting and acoustic space evaluation, utilizing theoretical and interactive techniques. In addition, new interaction paradigms are under consideration.

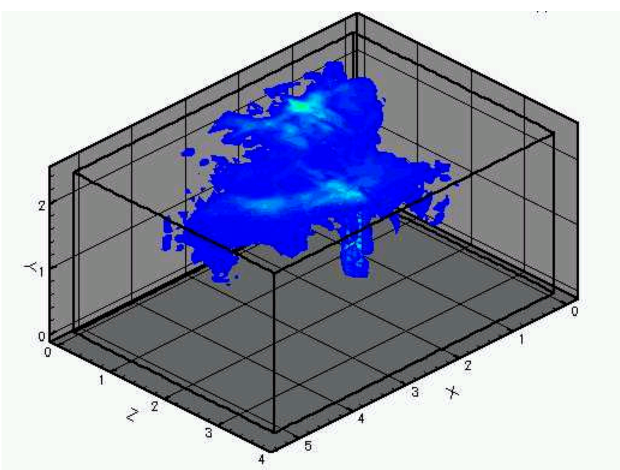
Principal investigator: Julie Dorsey
Sponsor: National Science Foundation

• MODELING AND RENDERING OF WEATHERED MATERIALS Photorealistic image synthesis is an important problem for such diverse fields as architecture, scientific visualization, simulation systems, lighting and industrial design, remote sensing from satellites and robots, and entertainment and advertising. An important, largely unexplored area of computer image generation is the simulation of weathering and its effects on appearance. Weathering results from the interaction of the environment with the materials in the world. Existing models of materials in computer graphics assume that the materials are in pristine condition. This research considers the development of computer graphics techniques for modeling and rendering weathered materials.

Principal investigator: Julie Dorsey
Sponsor: National Science Foundation

♦ **<u>Indoor Air Quality, Building Ventilation, and Building Environment Modeling</u>**

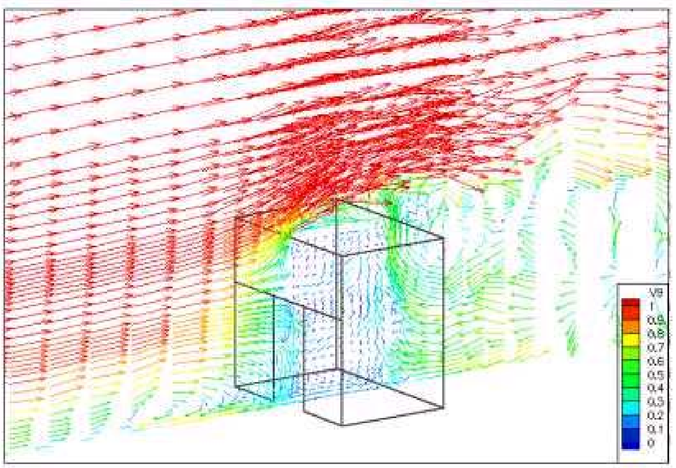
• A PARTICLE MODEL FOR LARGE EDDY SIMULATION In order to predict indoor air quality, it is essential to simulate the particle trajectories of contaminants in and around buildings. The information can be used to determine the best locations for placing sensors so that the building systems can provide best air quality. The study uses the Lagrangian model to trace the particle motion in a large eddy simulation program. Drag, buoyancy and Brownian forces are being considered in the motion equations. The modeling of momentum and energy exchange between air and particles is also established according to the theoretical analysis and experimental data.



Contaminant distribution in a room

Principal investigator: Qingyan Chen
Research assistant: Mingde Su
Sponsor: MIT Lincoln Laboratory
Dates: July 2000 – June 2001

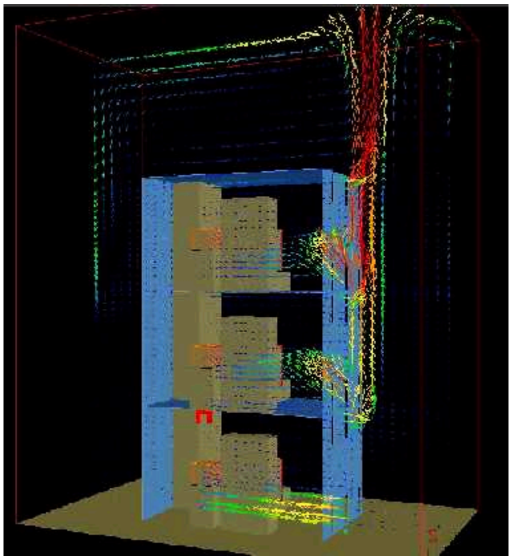
• LARGE EDDY SIMULATION OF AIRFLOW IN AND AROUND BUILDINGS Large eddy simulation (LES) could be a next-generation tool to predict airflow in and around buildings, because LES is universal, has few or no adjustable model coefficients, and can provide more flow information. We are developing different LES dynamic subgrid models that are suitable for both indoor and outdoor airflows, and advance numerical algorithm to reduce computing costs. The new models and algorithm are being applied for natural ventilation design in buildings.



Instantaneous velocity and temperature distribution in a room predicted by LES.

Principal Investigator: Qingyan Chen
Research Assistants: Wei Zhang, Yi Jiang, and Mingde Su
Sponsors: National Science Foundation, Center for Indoor Air Research and Archilife Research Foundation
Dates: July 1997 – September 2002

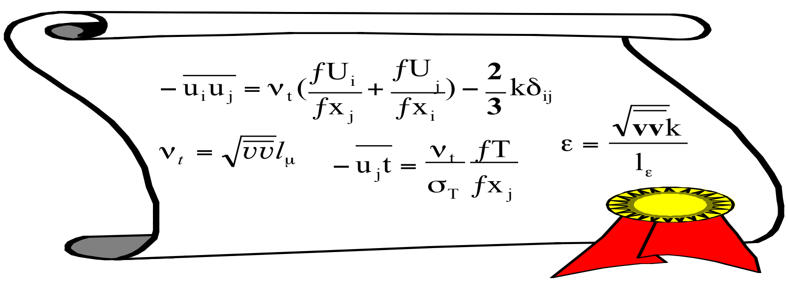
• DESIGN ANALYSIS FOR SINGLE-SIDED VENTILATION A challenge of natural ventilation design is to control the mechanisms of wind and temperature in order to develop the required indoor environment conditions. This study focuses specifically on the principles of single-sided ventilation design using computational fluid dynamics (CFD) techniques. Simulations are performed under various wind and temperature conditions. Theoretical and empirical models as well as experimental measurements are applied in order validate the CFD model. This investigation will provide the trends necessary to develop a set of design criteria for natural ventilation.



Single-sided natural ventilation in a building

Principal investigators: Qingyan Chen
Research Assistant: Camille Allocca
Sponsor: National Science Foundation
Dates: September 1999 – January 2001

- A NEW TURBULENCE MODEL FOR AIRFLOW PREDICTION IN A ROOM Accurate prediction of air movement in a room is indispensable for designing high-quality ventilation systems. The computational-fluid-dynamics (CFD) technique can be used to calculate the distributions of air velocity, temperature, turbulence, and contaminant concentrations in a room. However, the computed results sometimes disagree with experimental data. In order to improve the performance of the CFD technique, we have developed a new turbulence model that can be used for accurate prediction of natural, forced, and mixed convection in rooms.



Formulation of the new model.

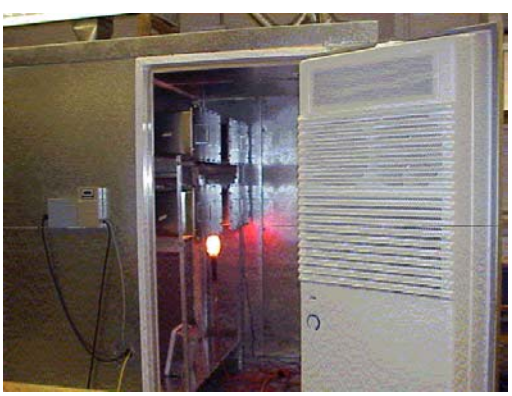
Principal investigator: Qingyan Chen
Research assistant: Weiran Xu
Sponsor: National Science Foundation
Dates: September 1995 – July 1998

• BUILDING MATERIAL EMISSIONS AND INDOOR AIR QUALITY Since over 60% of indoor pollution comes from building materials, it is important to reduce material emissions for better indoor air quality. We have developed several computer models to calculate the emissions from building materials, and have validated the model by the experimental data obtained from both small and large test chambers. The models can replace traditional measurements of material emissions in a small chamber. The research is in collaboration with the National Research Council Canada.

A large-scale stainless-steel chamber used to test material emissions.

Principal investigator: Qingyan Chen
Research assistant: Xudong Yang
Sponsor: National Science Foundation
Dates: July 1996 – June 2000

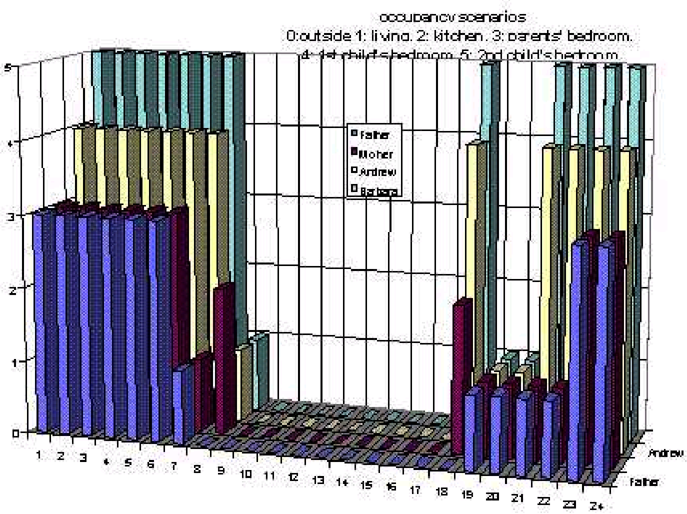
• MODELING VOLATILE ORGANIC COMPOUNDS (VOCs) SORPTION ON BUILDING MATERIALS Building materials are not only a source of volatile organic compounds (VOCs) but also affect the transport and removal of indoor VOCs by sorption (adsorption and desorption) on the interior surface. The re-emission of adsorbed VOCs from building materials can elevate VOC concentrations and indoor air quality in buildings during the entire service life of a building. This investigation is to determine accurately the sorption of VOCs by building materials and the impact of sorption on IAQ.



Four small-scale test chambers used in sorption tests sitting in a conditioned big box

Principal investigators: Jianshun Zhang and Qingyan Chen
Research Assistant: Jinsong Zhang
Sponsor: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
Dates: April 1999 – May 2001

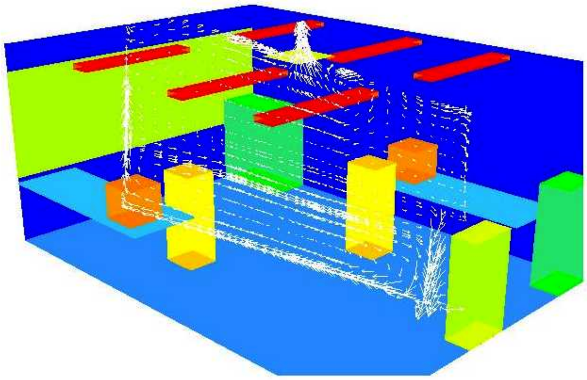
• MODELING CONTAMINANT EXPOSURE AND INDOOR AIR QUALITY IN A SINGLE-FAMILY HOUSE This study evaluates the indoor air quality in a small single-family house by using computational fluid dynamics (CFD) and a variety of mixing models. CO2, CO, NO2, formaldehyde (HCHO), and vapor are tracked throughout the house to determine the concentration levels, occupational dosing, and personal exposure for a family of two adults and two children. Variations in metabolic activity, smoking, gas stove cooking, and showering make exposure very dependent on the individual's location in the house due to pollutant migration.



Occupancy scenario in a house

Principal investigator: Qingyan Chen
Research Assistant: Jeffrey Huang
Sponsor: Electricite de France
Dates: September 1999 – January 2002

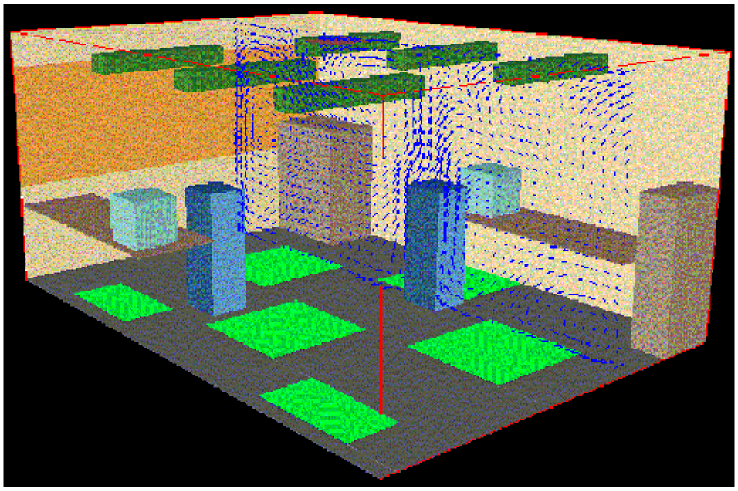
• DESIGN GUIDELINES FOR DISPLACEMENT VENTILATION Displacement ventilation can provide better indoor air quality and can save energy in buildings with a comfortable environment compared with mixing ventilation. We have conducted experimental measurements and computer simulations to study the system performance in U.S. buildings where the cooling load is high. The study has also developed design guidelines for the U.S. buildings.



Air distribution in an office with displacement ventilation.

Principal investigators: Qingyan Chen and Leon Glicksman
Research Assistants: Xiaoxiong Yuan and Shiping Hu
Sponsor: American Society of Heating, Refrigerating and Air-Conditioning Engineers
Dates: September 1996 – August 1998

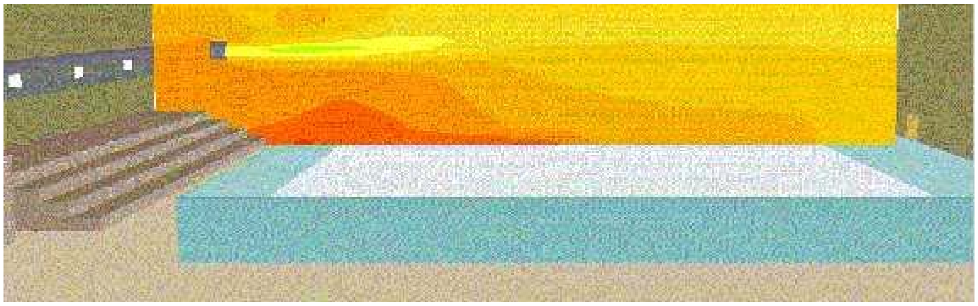
• FLOOR-SUPPLY DISPLACEMENT VENTILATION Traditional side-wall-supply displacement ventilation generates recirculations in the occupied zone, although it provides better indoor air quality than mixing ventilation. The recirculation presents the risk of cross infection. This investigation studies floor-supply displacement ventilation by using perforated floors and floor diffusers. This research aims at high cooling loads without draft risk. This research is being conducted by both experimental measurements and computer simulations.



Airflow in a room with floor-supply displacement ventilation

Principal investigator: Qingyan Chen
Research Assistant: Nobukazu Kobayashi
Dates: September 1999 – May 2001

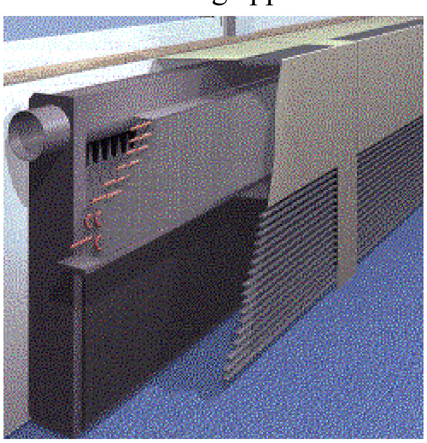
• INDOOR AIR QUALITY IN ICE RINKS The study, in collaboration with Professor John Spengler's group at Harvard School of Public Health, is to assess the ventilation system effectiveness in the community and college ice rinks in North America by the computational fluid dynamics (CFD) technique. Detailed in-situ measurements on indoor air quality and air distribution have been conducted to verify the CFD results. The investigation will develop guidelines for the ventilation system design and operation.



Carbon monoxide distribution in a typical section at an ice rink.

Principal investigators: Qingyan Chen and John D. Spengler
Research Assistants: Chunxin Yang and Phil Demokritou
Sponsors: Frank J. Zamboni & Co., Inc., New England Ice Skating Managers Association, the Ice Skating Institute, Ice Skating Institute of America Education Foundation, and the Nova Scotia Sport and Recreation Commission
Dates: September 1998 – September 1999

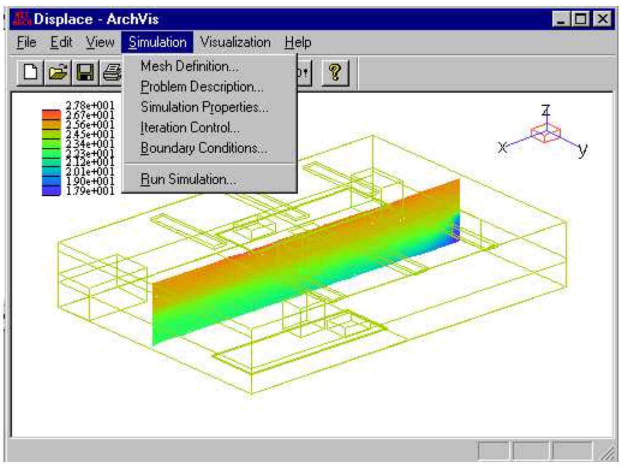
• SIMPLIFIED METHODS FOR INDOOR ENVIRONMENT MODELING The American Society of Heating, Refrigerating and Air-Conditioning Engineers is sponsoring two research projects to determine indoor environment quickly. One project is to predict the three-dimensional distributions of air velocity, temperature, and contaminant concentrations in the room on a personal computer (PC). The other project develops a simplified numerical model to specify complex diffuser boundary conditions for numerical simulations of room air motion. The methods are being applied to a variety of practical problems.



Sketch of a diffuser.

Principal investigators: Qingyan Chen and Leon Glicksman
Research Assistant: Jelena Srebric
Sponsor: American Society of Heating, Refrigerating and Air-Conditioning Engineers
Dates: September 1997 – July 2000

• GRAPHICAL INTERFACE FOR INDOOR ENVIRONMENT DESIGN Simple computer programs are being developed for the architectural and engineering students to design building environment. Currently, the development focuses on the modeling of thermal comfort and air quality in and around buildings. The program can be run in Window 98 and NT personal computers with a graphical interface for data pre- and post- processing. The interface can serve different computational fluid dynamics codes.



The program interface.

Principal investigator: Qingyan Chen
Research Assistant: Charles Broderick, III
Sponsor: National Science Foundation and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
Dates: July 1996 – June 2000

♦ **Sustainable Building Design**

• ALLIANCE FOR GLOBAL SUSTAINABILITY MIT has a major international effort underway in cooperation with the Swiss Federal Institute of technology and the University of Tokyo dealing with global sustainability. In the buildings area there are research projects underway on tools for sustainable design and indoor air quality. The design tools are intended as simple intuitive graphical tools that designers and city planners can use in the initial phases of design. The tools will present the implications of energy, renewable materials, and air quality, among others, for different projected designs. Graduate students are presently developing graphical representations of the sustainability factors and algorithms for rapid real time calculation of sustainability indices. In a parallel effort researchers and students from the three universities are coordinating a research effort to relate the materials used in a building interior with the level of pollutants and indoor air quality.

Principal investigators: Leon Glicksman, Julie Dorsey, Qingyan Chen, and Les Norford
Sponsor: Alliance for Global Sustainability

- ENERGY-EFFICIENT BUILDINGS IN DEVELOPING COUNTRIES We are identifying the most promising technologies for a generic residential building in developing countries, such as China. Several prototype designs of energy efficient systems and buildings are being developed. Attention is focused on urban area, such as Beijing and Shanghai. The work is in cooperation with Tsinghua University in Beijing, China. The emphasis on the work is to develop simple generic solutions that are appropriate to the local area, are very cost effective, and will be accepted by the local people.

A new design with good ventilation

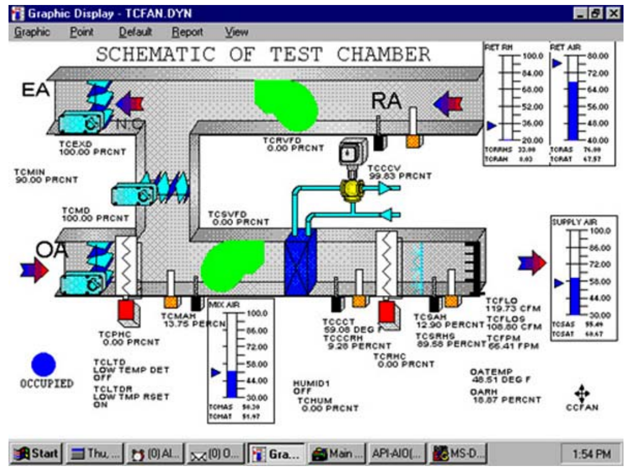
Principal investigators: Qingyan Chen, Leon Glicksman, Leslie Norford, and Andrew Scott
Sponsor: Kann-Rasmussen Foundation and KHI

❐ FACILITIES

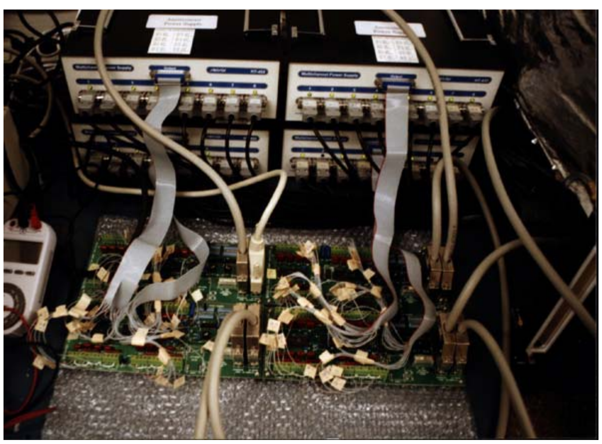
Students and faculty in the Building Technology Program have access to a wide range of facilities. The Program maintains its own laboratory spaces for research, computation and teaching. These include a full-scale environmental chamber, small-scale prototyping facilities, and advanced workstations. Projects are also performed in the Mechanical Engineering department's Heat Transfer Laboratory, in the Laboratory for Electromagnetic and Electronic Systems, in Civil and Environmental Engineering labs, and on-site in buildings. MIT's extensive system of networked computer workstations is also available.

Major Equipment
Two environmental test chambers
Two HVAC systems
A flow visualization system
A hot-sphere anemometer system
A tracer-gas system
A thermo-couple system
Three SiliconGraphics workstations

The environmental chamber.



The environmental chamber control system.



A part of the ADD boards for data acquisition

The tracer gas analyzer and sampler

Functions of the facilities
Indoor Air Quality
Thermal Comfort
Energy Conservation in Buildings
HVAC System Design and Control

In addition to various research projects, the facility is also used for teaching in the following subjects

4.411 Building Technology Laboratory
4.42J Fundamentals of Energy in Buildings
4.425 Energy in Building Design
4.427J Analysis & Design of HVAC Systems
4.481 Building Technology Seminar

❐ EDUCATION

Graduate students in the Building Technology program have earned undergraduate degrees in a variety of engineering disciplines, in architecture, and in the physical sciences. Many have had jobs ranging from electronic instrumentation to design of space-conditioning equipment for buildings to the Peace Corps. Despite the diversity of experience, all have shared both a keen interest in buildings and a thorough education in mathematics, physics and other technical subjects.

♦ S.M. in Building Technology

The Master of Science (S.M.) in Building Technology requires student to take one seminar on current research topics in building technology; one subject in applied mathematics; a major consisting of at least two subjects in a single field of specialization, chosen from thermal science, structures, materials, controls, or systems analysis; and a minor consisting of one subject from another field of specialization in building technology. Other fields may also be accepted for specialization if they are deemed appropriate for the program. Suitable subjects include engineering and technology courses and architecture workshops that combine building technology and architectural design. Total course credits for the S.M. is 66 units. An S.M. thesis is required for the degree. The thesis is carried out under the direct supervision of a faculty member in the program. The thesis topic is selected from a subject currently being studied by the faculty. In most cases this subject is part of a sponsored research project. Students can complete the S.M. in one and one half years, including the summer, although many stay two academic years.

♦ Ph.D. in Building Technology

Many students completing the S.M. degree in building technology, or with an appropriate Master's degree from another university will seek further studies under a Ph.D. program. Those admitted for study will immediately begin research work under the supervision of a faculty member while taking course work. They will also be registered as a graduate student in the academic department most appropriate to their background and interests.

Most Ph.D. research projects will be a portion of a sponsored research program. The research comprising the Ph.D. thesis must involve an original, substantial contribution to the field of investigation. The thesis must result in advances in the state of the art that would merit publication in a respected, refereed technical journal in the field.

Along with the thesis, a Ph.D. student is required to complete a major and a minor program of study as approved by an interdisciplinary thesis committee and successfully complete a qualifying examination. The minor program is in an area within Architecture or Engineering distinct from the major. It is expected that several subjects in the program of study would be in the student's academic department. The student must also demonstrate competence in verbal and written English and fulfill a program which assures adequate competence in mathematics.

It is expected that the Ph.D. program will require two to two-and-one-half years in residence beyond the S.M. degree. Only under very special circumstances will students be allowed to carry out any of their thesis research while not in residence at MIT.

♦ Advanced Degrees in Related Fields

Students may earn a degree in an engineering or science discipline while performing research under the direction of Building Technology faculty. These students must fulfill the course requirements of their home department. Students from Civil and Mechanical Engineering and from the Technology and Policy Program have participated in Building Technology research projects in this way. Some students have elected to complete the degree requirements for both the SMBT and an S.M. in another discipline and have earned two degrees; this requires substantial course work and a thesis acceptable to both disciplines.

Some students wish to combine studies of building technology with training in architectural design. These students have several options: students already holding a professional architecture degree may apply to the S.M. in Architectural Studies program and specify a concentration in building technology; students seeking a professional architecture degree may apply to the Master of Architecture (M.Arch) program and focus on building technology via required and elective courses as well as a thesis topic; and students may apply for admission to both the Masters of Architecture and Building Technology Programs. Students admitted to both programs will join each in sequence rather than simultaneously, completing the degree requirements of one before beginning the other; the S.M. in Building Technology and M.Arch degrees cannot be awarded simultaneously due to the demands of the S.M. in Building Technology thesis research and architectural design studio.

❐ FINANCIAL AID

Admission decisions are made without reference to student financial needs. Many students are offered research assistantships for at least a portion of their time at MIT. This form of financial support covers tuition and provides a monthly stipend to offset living expenses. Because research assistants are working not only to fulfill a thesis requirement but to meet contractually obligated research objectives, the research assistantship requires essentially full-time effort. Teaching assistant positions in building technology courses are also available.

❐ BUILDING TECHNOLOGY FACULTY

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❒ ADMISSIONS

DEADLINES - Admission to the S.M. and Ph.D. programs in Building Technology is by competition among the candidates for the places available. Applications are reviewed twice each year, with deadlines of December 15 for students desiring to start in the Fall (September) semester and September 15 for those who would prefer to start in the Spring (February) semester. It is the responsibility of the applicant to be sure that the completed application forms and all supporting materials are received on time. Applications from exceptionally well qualified students may be reviewed at other times if there is adequate justification.

Applicants will be notified by mail of the Admission Committee's decision the first week of April for September admission and the first week of December for February admission.

REQUIREMENTS - The Admissions Committee requires all of the following eight items in order to process an application for admission:

1. A completed "Graduate Application for Admission and Financial Aid." This application asks for the applicant's "degree objective" and "area of research interest." All applicants to the program should list their initial "degree objective" as S.M. or Ph.D. in Building Technology. Under "area of research interest" each applicant should list the area(s) of study within the program in which he or she has the greatest interest.

2. Official transcripts of the applicant's academic record.

3. Three letters of recommendation from teachers, professionals and/or other persons familiar with the applicant's work.

4. A statement of academic objectives. This should include detailed information on why the applicant wishes to enter the Building Technology program, how the applicant's background has prepared him or her to undertake study for this degree, and the applicant's career intentions.

5. A non-refundable application fee, as specified in the application. Payment should be made by check or money order, payable to the Admissions Office, MIT.

6. A research paper or portfolio of the applicant's work may be submitted to aid the admissions committee. It is not required.

7. Students whose first language was not English-regardless of their present residency or citizenship-must submit the results of the Test of English as a Foreign Language (TOEFL). The Admissions Committee regards English proficiency as an important criterion for success in the S.M. Building Technology program. The Institute recommends a minimum score of 600 for the written test and 250 for the computer-based test. Original test scores should be included with the application; if not, they must be received in time to support review of the application.

8. The Graduate Record Examination is required for all the students applied to the Building Technology Program.

You may also print a PDF version of the current graduate application at the following internet address:

http://mit.edu/admissions/www/

❒ FURTHER INFORMATION

Further information is available in the homepage of the Building Technology Program:

http://mit.edu/bt/www/index.html

Assistance with admissions questions can be obtained at the following web sites:

SmarchS: http://architecture.mit.edu/degrees/masters/smarchs/areas.html#archtech
SMBT: http://architecture.mit.edu/degrees/masters/smbt/index.html
PhD: http://architecture.mit.edu/degrees/phd/bt.html

If there are further admissions specific inquiries, contact the admissions coordinator:

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617-253-8993 (fax)
yammie@mit.edu (email)

Other inquiries should be directed to individual faculty members, who could be reached at:

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