Activities,
Accomplishments
& Recognitions

BUILDING & FIRE RESEARCH LABORATORY

BFRL

2000 - 2001

NIST
National Institute of Standards and Technology
Technology Administration,
U.S. Department of Commerce

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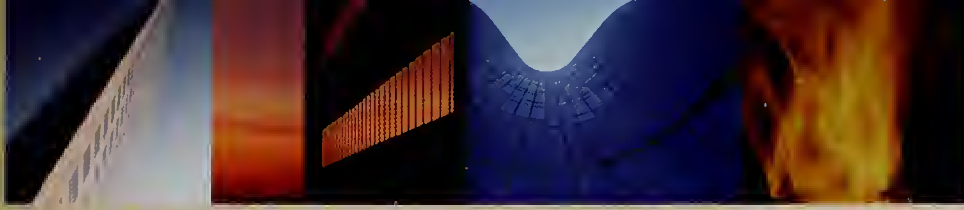


BFRL AT A GLANCE

BFRL MISSION

Meet the measurement and standards needs of the building and fire safety communities.

BFRL VISION

The source of critical tools – metrics, models, and knowledge – used to modernize the building and fire safety communities. Our programs are identified, developed, carried out, the results implemented, and consequences measured in partnership with key customer organizations.

BFRL GOALS

The building and fire communities (builders, suppliers, owners and fire safety professionals) strive to increase productivity, construct better buildings, faster, at lower cost, own buildings that are fire safe, less costly to operate, and have less impact on the environment. To meet the needs of these communities BFRL is focussing on four goals.

- **Advanced Construction Technology:** to enable technology-based innovation to modernize and assure safety of construction. The strategy to meet this goal includes process innovation addressing construction integration and automation, and product innovation addressing construction systems and safety.
- **High Performance Building Materials:** to provide the means for evaluating and predicting the performance of next generation building materials. The strategy to meet this goal is to develop and apply metrics for service life and performance prediction and establish science-based tests and data resources.
- **Enhanced Building Performance:** to provide the means to assure buildings work (better) throughout their useful lives. The strategy for meeting this goal is to provide knowledge, measurements and tools to optimize building life cycle performance.
- **Fire Loss Reduction:** to enable engineered fire safety for people, products, facilities and enhanced firefighter effectiveness. The strategy to meet this goal is to reduce the risk of flashover in buildings, to advance fire safety technologies, to make advanced measurements and develop predictive methods.

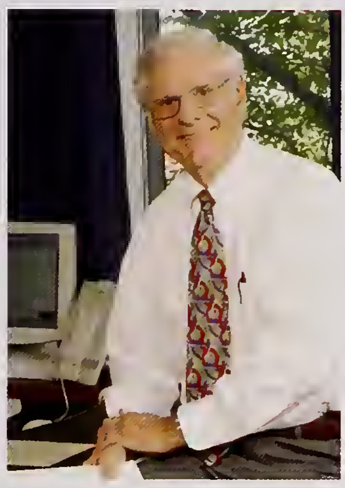
BFRL RESOURCES

- 150 full time staff (126 professional) with expertise in:
  - measurement,
  - material and system performance,
  - mathematical modeling,
  - non-destructive testing, and
  - diagnostics
- $31 million annual budget
- Unique facilities including:
  - Integrating Sphere UV exposure chamber
  - Electron microscope
  - Tri-directional test facility
  - 12 million pound test machine
  - Solar tracker
  - Large scale fire test facility
  - Environmental chambers

BFRL WEB SITE

www.bfrl.nist.gov

Director's MESSAGE



This is the first report of the NIST Building and Fire Research Laboratory (BFRL) in the new century. It reflects major changes that we are making to serve our customers and stakeholders better. We serve those who design and build facilities and the many products of which they are constructed; those who own, occupy, operate and maintain them; and those who oversee them for fire, life safety, and risk management. The changes we are making include sharpening our vision and mission, narrowing our program on four specific goals, and strengthening our resources to address these stretch goals. We are in the process of working with customers and stakeholders to develop strategies and roadmaps for achieving each of them. The work described herein reflects our progress in this effort. This report presents the impacts, accomplishments, recognition and activities of our staff over the two previous years, and a view of where we are heading.

These are challenging times. The attacks of September 11, 2001, on the World Trade Center and the Pentagon have had a great impact on the Nation and the economy, and also on the entire BFRL staff. We responded by redirecting $2 million to a number of projects aimed at deriving lessons learned from the attacks, and providing the knowledge, tools and data that building owners, designers, fire and emergency responders, and occupants need to operate more effectively and safely in the future. We are providing leadership in the development of a broader public-private response effort as well.

This is a time of great change for the building and fire safety communities. Owners want facilities that are delivered faster and at less cost, perform better over their life cycles, positively influence the productivity of those who occupy them, and are sustainable. Additional "drivers" include globalization; rapid advances in information, sensing, simulation and automation technologies; and increasing pressures for resource and environmental management.

In all we do, we seek to understand these changing needs of those we serve, and focus our efforts to achieve best value for the public investment we are entrusted to manage. Our four goals address advancing construction technology, opening the way for high performance building materials, enabling enhanced building life cycle performance, and reducing vulnerability to and losses from fire and other disasters. In each of them, we are partnering with private and public sector bodies to assure that what we do achieves the intended consequences in a timely and cost-effective manner.

We recognize that BFRL is but one of a number of players involved in advancing the performance, productivity and cost-effectiveness of built facilities. Our primary focus is on measurement and prediction. Increasingly, we see ourselves as a node in a larger network of organizations dedicated to better, more efficient, safer and less costly facilities. We are constantly looking for opportunities to extend our impact through partnerships and collaborations, and encourage your thoughts and suggestions on how, working together, we may be an even greater influence for beneficial change and growth.

BFRL is a closely-knit community of extraordinarily talented and dedicated public servants. I hope that after reading this report you will be motivated to develop even closer relationships with this outstanding collection of people. We love what we do and having the opportunity to be of service to you. I urge you to visit our web site (*www.bfrl.nist.gov*) and look forward to hearing from you.

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ADVANCED CONSTRUCTION TECHNOLOGY

To enable technology-based innovation to modernize and assure safety of construction.

The strategy to meet this goal includes process and product innovation.

The first element, process innovation, addresses construction integration and automation (CONSIAT).

Construction Integration and Automation Technology (CONSIAT)

INTENDED OUTCOME AND BACKGROUND

The intended outcome of CONSIAT is to achieve breakthrough cycle time and lifecycle cost reductions in the delivery of construction projects by providing, within five years, the critical science-based performance measurement tools that will enable early industry integration and automation of the construction process.

The Construction Industry Institute (CII) – an organization with about 100 members representing the Nation's leading owners, contractors, and suppliers of constructed facilities – has made the development of Fully Integrated and Automated Project Processes, FIAPP, a top priority. However, the construction industry faces special challenges including low R&D investment, the fragmentation of the industry, and the strong project-oriented nature of its processes.

The construction industry has already achieved reductions of 20 percent or more in project delivery time, costs, and worker injuries through implementation of best practices over the past decade, but the industry is dedicated to doubling these gains. Achieving FIAPP requires moving beyond best-practices to considering breakthrough process and product innovations.

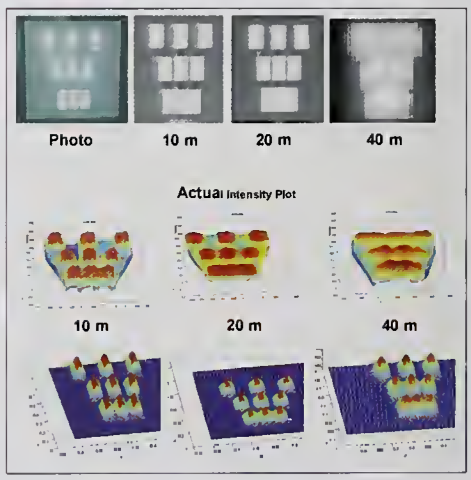
The CONSIAT program will produce the critical science-based performance measurement tools to enable: integration of construction site metrology data and other field information into project information management systems; delivery of just-in-time information to guide field operations; and automation of the construction process.

CII, with the support of NIST, has created FIATECH, a collaborative, not-for-profit consortium that will conduct leveraged research and development in partnership with suppliers, with firms in the software/information technology industries, and with the public sector. NIST is working in close partnership with the FIATECH Consortium to maximize the relevancy of the projects and the leveraging of resources on both sides, and to minimize the time to implementation of the program results. NIST is also participating in the FIATECH-led Capital Projects Technology Roadmapping effort. The resulting industry roadmap will help guide the CONSIAT program.

ACCOMPLISHMENTS

LADAR-scanned Long-Range Bar Codes Developed

One potential breakthrough technology that stands to revolutionize construction surveying and status monitoring is known as laser range imaging. The device used to obtain the field data is known as a LADAR (Laser Distance and Ranging). With LADAR it is possible to rapidly capture true 3D data for an entire construction scene. Essentially, the LADAR acquires hundreds of thousands to millions of survey "shots" – creating a point cloud – that covers a field of view from the sensor location. In the land surveying and stake-out business, such point clouds could be considered as instantaneous "stake-outs" with a degree of precision



Intensity plots of retroreflective bar codes.

and speed that lends itself both to web-based volume take out determination and billing and, even more powerfully, enables the automation of the machines that move the dirt. In the case of constructed facilities, such data could be further processed to create accurate 3D surface models from which the positions and orientations of individual parts could be deduced automatically to high accuracy through object recognition—thus producing automatic "as-built" models of the facility. In short, LADARs will likely pave the way for improved survey accuracy and speed, will make possible automated construction status assessment and will enable the first instances of truly automated construction processes.

Object recognition is one of several key tools necessary for widespread implementation of LADARs. Various methods of object recognition exist, but they require intensive manual intervention and are limited in scope. Furthermore, because point cloud data carry no intelligence, current object recognition algorithms – which aim to extract knowledge of manufactured components within a scene of several million data points – must operate on an entire data set. From the viewpoint of dramatically enhancing this process, it would be most advantageous if those components could, at the very least, indicate their ID number and approximate location within the point cloud. To that end, a hybrid LADAR is needed—a LADAR that can simultaneously acquire "intelligent" information about an object in addition to existing generic spatial position. The combined information from this type of sensor would be a major step towards automatic object identification, or auto-ID.

Efforts in FY01 at NIST were focused on using the intensity information that is currently obtained by the LADAR to read "macro" bar codes. The effects of distance and angle of incidence of the laser on the intensity value were examined. The investigation included the maximum distance at which the bar codes were readable, the determination of maximum bar size and bar spacing at 100 m, and the investigation of image processing techniques. The work in FY01 has already produced the ability to read 1 byte of data at 40 m using purely passive macro bar codes fabricated from retroreflective material. A 1 byte barcode measures 572 mm using current technology. Because the system is passive, it has the capability of 24/7 auto-ID without the use of any auxiliary power requirements.

Planned work will further investigate the effect of the angle of incidence on the intensity value, establish target symbology for construction sites, and automated extraction of bar codes in a scene.

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Use of Standard Interface Protocols to Transfer Data to and from Construction Site Demonstrated

Ms. Karen Furlani, along with colleagues Mr. DeWitt Latimer, Dr. Kent Reed, Mr. Robert Lipman and Mr. Andreas Besier, and Dr. Dave Gilsinn of NIST's Information Technology Laboratory, demonstrated the use of standard interface protocols for the transfer of real-time metrology and metrology-based data to and from a construction site. The demonstration involved tracking the final location of structural steel members at the Emission Control System addition to the Large Fire Laboratory on the NIST, Gaithersburg campus.

The steel-tracking, field-data collection system, called Comp-TRAK, operates via an interactive web interface running on a belt-wearable computer. The system integrates field sensors, for real-time data collection of part identification and 3-D coordinate measurements, and a wireless data link for communications, with a remote server hosting a Part Locator Service (PLS) and Project Information Management System (PIMS). A user in the field scans a bar code attached to a steel member for the part ID. The ID is used as a key to retrieve part information from the PIMS, including a 3D Virtual Reality Markup Language (VRML) model of the scanned member with fiducial point locations marked to guide a user through the collection 3-D coordinate data for at least three fiducial points. A field-agent module transforms the coordinate data to a global site frame based on the set-up calibration of the field measurement system and sends the data to the PLS. The PLS returns the location of the member computed from the transformed coordinate data and the known fiducial-point characteristics. The field-agent module can then register the part location with the PIMS and either end the session or track a new steel part. The part information in the PIMS, including the VRML models, and the functionality of the PLS are consistent with the CIMsteel Integration Standards Release 2 recently endorsed by the American Institute of Steel Construction for representing information about structural steelwork. (See the related article on Electronic Data Interchange for Steel Construction.)

The successful implementation and integration of the Comp-TRAK, PLS and PIMS systems demonstrate the feasibility of automatically transferring information in real-time from the construction site to project management databases and associated applications, specifically for the identification and tracking of structural steel subsystems.

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Electronic Data Interchange for Steel Construction

Mr. Robert Lipman and Dr. Kent A. Reed have been working to support the American Institute for Steel Construction (AISC) Electronic Data Interchange Initiative. The purpose of the initiative is to create a means for collaboration and data sharing among the various parties involved in steel construction. Dr. Reed participated in the AISC task force whose final recommendation to endorse Version 2.0 of the CIMsteel Integration Standards (CIS/2) was adopted by the AISC Board of Directors. These product data standards were developed in Europe and the U.K. primarily to support steel design, analysis, detailing, and fabrication activities.

This year, Dr. Reed assessed the capability of the CIS/2 product data model to support construction site activities. He has authored a report summarizing this assessment and making recommendations for enhancements to the standards. This work shows that using CIS/2-conforming translators in project information management systems would enable erectors and construction managers to reuse information already becoming available in electronic form from the software used by designers and fabricators. This reuse would eliminate the current laborious, time-consuming, and error-prone manual task of extracting information from drawings and schedules for reentry into electronic form.

Mr. Lipman has been participating in the AISC-facilitated technical workshops and CIS/2 translator implementation activities. His technical work culminated this year in the creation of the CIS/2 Visual Interoperability Testbed. This Web-based service translates a CIS/2 file of a steel structure into a 3D interactive model in the form of a VRML (Virtual Reality Modeling Language) file. Users can visualize CIS/2 files and make them available on the web and software developers can verify their CIS/2 export capabilities. Commercial software vendors immediately began using this service as they developed and tested their translators.

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The second strategic element for achieving the advanced construction goal of enabling technology-based innovation to modernize and assure safety of construction deals with product innovation.

Construction Systems and Safety (CONSAFE)

INTENDED OUTCOME AND BACKGROUND

The intended outcome of CONSAFE is to achieve life-cycle cost reductions and enhanced public safety for new and existing construction by providing, within five years, the critical science based performance measurement tools that will enable early industry adoption of innovative constructed systems with assured safety and performance.

There are large, unmet industry and public safety needs in construction. Among the highest priority goals identified by the U.S. industry are the need for construction cycle-time reductions in the delivery of constructed facilities, life-cycle cost reductions in the maintenance and repair of such facilities, and increases in facility durability and flexibility to meet economic and sustainability objectives.

In addition, there is a critical need to reduce the debilitating impact of extreme (natural and man-made) events to the U.S. economy and the public-at-large. Total property losses from recent disasters – including earthquakes, hurricanes, tornadoes, flooding, and fires – exceed $22 billion per year.

CONSAFE will be conducted in two major thrusts. The first will develop measurement-based predictive models and performance criteria for innovative constructed systems. This work encompasses the current priority topics listed below:

- curing of high-performance concrete to ensure strength and durability;
- mitigating explosive spalling of high-performance concrete exposed to fire;
- structures with passive and semi-active structural control devices;
- strength, ductility and fire performance of Fiber Reinforced Polymer (FRP)-reinforced structures;
- NDE methods to assess condition of FRP-reinforced structures; and
- innovative structural connections to automate construction.

The second thrust will develop measurement- and reliability-based simulation models to predict structural performance under extreme loads. The current priority topics include:

- extreme wind loads and effects on structures accounting for space-time variation, directionality and topography;
- fire performance of concrete, steel and FRP composite structures;
- optimal performance of structures with control systems under earthquake and wind loads; and
- progressive structural collapse under multiple threat scenarios.

NIST will conduct post-disaster and construction failure investigations of selected events to document facility performance, examine the adequacy of current standards and practices, and identify research needs to mitigate the impacts of future disasters/failures through improved standards and practices.

ACCOMPLISHMENTS

Next Generation Standards for Wind Loads

Electronic provisions for wind loads entail the use of large aerodynamic and climatological databases and can result in structures that are considerably safer and more economical than structures designed by using conventional provisions. Originally proposed by NIST, their use is accepted by the current ASCE 7 Standard. Software for calculating peak effects from aerodynamic databases is complete and operational. The methodology used to develop the software, and typical results, were presented in a paper given at the 3rd European Conference on Wind Engineering in July, 2001. Software for including effects of wind directionality has also been completed. In preparation for the development of a reliability-based module for the assessment of building safety under wind loads, a paper is being prepared on sampling errors in the estimation of peaks in 20 min. to 1 hour records obtained from wind tunnel pressure measurements. Preparatory work for extension of database-assisted design to dynamically sensitive structures was performed. Data to be used in this extension have been selected from a menu offered, within the framework of a joint project, by the University of Western Ontario.

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Seismic Performance of Buildings with Hybrid Control

Large earthquakes routinely result in structural damage, casualties, significant economic losses, and disruptions in critical life-supporting facilities. Such consequences can be reduced through the use of innovative systems that assure safety and performance. Installation of control devices, such as seismic isolation and energy dissipators, in numerous buildings throughout the world has proven that they enhance structural performance, allowing the structure to survive extreme loading and assuring the safety of the buildings' occupants. Even when properly designed, there are limitations to how well isolated and controlled structures perform. Some of these limitations may be overcome by using hybrid control systems, which combine passive or semi-active energy dissipators with isolation systems; however, the use of semi-active devices for this purpose requires additional studies to fully understand their performance.

Dr. Fahim Sadek, research associate, and Dr. Michael A. Riley, research structural engineer, are developing analytical models and control algorithms for predicting the response of buildings with hybrid control systems. This study, which is a joint effort of NIST, Southern Methodist University (SMU), and the Polytechnic School of Tunisia, has developed an innovative approach to controlling hysteretic structures using stochastic linearization and static output feedback. Recent results were published at the Society for Experimental Mechanics, Conference on Structural Dynamics in the paper "Stochastic Linearization for Control of Hysteretic Structures Using H_∞ Algorithm," by M. Ben Ftima, F. Sadek, S. El-Borgi, and M. Riley. This publication describes the analytical models and control algorithms that were developed for nonlinear structures.

A series of Matlab and Simulink-based programs has been developed to simulate the performance and response of structural systems with nonlinear behavior, and controlled with passive, active, or semi-active control devices. These programs can model various semi-active and passive devices including variable viscous dampers, magneto-rheological dampers and a variety of isolation devices. The programs use a variety of algorithms, including H_∞, linear quadratic regulator and sliding mode control to regulate the control devices. The programs are being used in numerical studies in which the performance of various combinations of structures, devices and algorithms is being compared. This study will determine which systems are cost-effective and what classes of algorithms best improve the performance of controlled structures. The study will also identify the types of buildings that will benefit the most from using hybrid systems. The final result of this effort will be design guides and simulation tools to assist practitioners who are designing buildings that are protected with hybrid systems.

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Strength, Ductility and Fire Performance of FRP-reinforced Structures

Much of the U.S. infrastructure is in need of repair or replacement as a result of damage caused by heavy use and exposure to the environment. Additionally, some of the nation's infrastructure facilities are in need of retrofit to either increase their capacity or to improve their seismic performance. The use of fiber-reinforced polymer (FRP) composites is emerging as an economical solution to the repair and retrofit of reinforced concrete structures.

BFRL's current efforts focus on the use of FRP in strengthening concrete masonry walls, one of the most common forms of construction in the U.S. This strengthening takes the form of thin glass fiber rods, epoxied into groves cut in the mortar joints or the concrete blocks, and can be applied to existing (as opposed to new) construction. These near-surface mounted rods cause minimum change in the appearance of the walls, yet they provide significant improvement in strength and deformation capacity. Research in 2001 concentrated on bond and anchorage of the rods to mortar or concrete, and strengthening against out-of-plane bending, as encountered under wind, blast or seismic loads. With proper bonding, the rods could develop their full tensile strength, and walls that normally could not withstand their own weight when placed sideways, could resist several times their weight before the rods ruptured.

Bond strength test of glass fiber rods epoxied in mortar joints of concrete blocks.

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Quantitative NDE of FRP Using Infrared Thermography

Nondestructive evaluation (NDE) techniques are required to ensure desired performance of FRP materials when used to repair or retrofit concrete and masonry structures. Nondestructive testing of thin laminated FRP bonded to concrete presents, however, a variety of difficulties due to material characteristics such as anisotropy, non-magnetic properties and high ultrasonic attenuation. Infrared thermography has been identified as a promising method for meeting this measurement need.

Infrared (IR) thermography remains a recent inspection method that needs further development to allow its standardization and widespread use for assessment of the condition of bonded FRP laminates. Ms. Monica Starnes and Dr. Nicholas J. Carino of the Structures Division are developing the technical basis required for a standard methodology for testing of FRP strengthened structures using IR thermography. The researchers used finite-element modeling to investigate the effects of various variables on the thermal response of simulated defects in FRP laminates applied to a concrete substrate. The studies focused on establishing the potential for quantitative infrared thermography, that is, not only detecting a flaw but also being able to describe its physical characteristics. Controlled-flaw experiments are being conducted to verify the finite-element predictions.

Ms. Monica Starnes using an infrared camera to assess the condition of FRP laminates bonded to concrete.

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HIGH PERFORMANCE BUILDING MATERIALS

To provide the means for evaluating and predicting the performance of next generation building products.

The goal of High Performance Building Materials is to provide the means for evaluating and predicting the performance of next generation building products. The strategy to meet this goal is to develop and apply metrics for service life and performance prediction and establish science-based tests and data resources.

The first focus of High Performance Building Materials is to develop scientific methods for measuring and predicting the service life of polymeric building materials. Accurate and accelerated methods for predicting the service life is an enabling technology to significantly reduce the time to market for new products.

Service Life Prediction of High Performance Polymeric Construction

INTENDED OUTCOME AND BACKGROUND

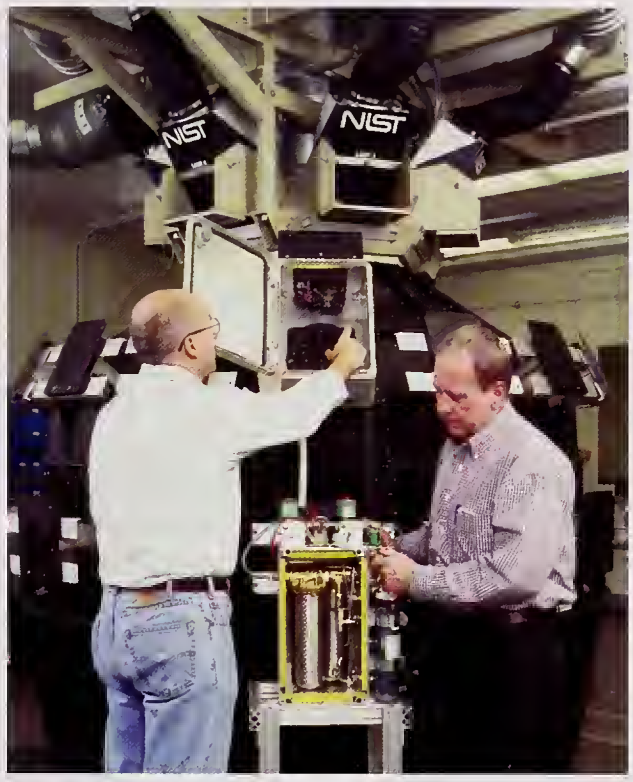
The intended outcome of the program on service life prediction of high performance polymeric construction is to improve the reliability and reduce the time-to-market for new products. The focus is on development and implementation of advanced methods and metrologies for quantitatively and reliably predicting the service life of existing and new products. This is accomplished by partnering with industry and other federal agencies in developing and implementing use-inspired scientific and technical advances in methodologies and metrologies for improving and advancing the appearance, service life and structural performance of polymeric construction materials.

Currently, time-to-market for many construction materials is controlled by the time required to generate a performance history for a product. Performance histories are established through a series of time-consuming field and laboratory exposure studies, typically taking between 5 and 15 years to complete. For U.S. construction companies to remain competitive, time-to-market, and hence, the time to generate these durability performance histories, must be reduced to months instead of years. The methodology that is being used to accomplish this target is called reliability theory and life testing analysis, which has proved successful in other industries.

The reliability-based methodology is being applied in five different, but highly overlapping, project areas including: appearance (the primary measure of durability for a coating system), coatings and pigments, composites, polymeric interphases and sealants. In all five areas, BFRL has strong interactions with industry and other NIST laboratories. Industry interactions include three on-going, or soon to be established, consortia involving approximately 20 Cooperative Research and Development Agreements (CRDA's) with the strong expectation that a fourth consortium (on advanced appearance metrologies as they relate to service life measurements) will be begun within FY02.

Reliability Approach to Prediction of the Service Life of Coatings

Over many decades, there have been repeated efforts to find a way of making reliable predictions of the outdoor performance of organic coating systems from the results of laboratory tests. The objective of this multi-year project led by Drs. Jonathon W. Martin, Jonnie Chin and Tinh Nguyen is to use a reliability-based methodology to link laboratory and field test results, as has been done successfully in the electronics and aerospace industries and in the medical field. The laboratory experiments are designed to cover the range of exposure conditions and degradation factors that coating products will be exposed to in service, and outdoor exposures are characterized in exactly the same manner. In this phase of the project, the feasibility of applying reliability theory to link outdoor performance and laboratory tests is being demonstrated for an epoxy coating. Since sample surfaces must be smooth and free from defects to allow use of sensitive techniques such as gloss and atomic force microscopy (AFM) measurements, a successful effort has been made to develop a procedure for producing smooth, defect-free films of different thicknesses. With the films produced, measurements have been made of water vapor sorption isotherms at 30° C to provide data needed for the next phase in which the carefully-characterized coatings will be exposed to precisely-known levels of the degradation factors (temperature, relative humidity, and UV light) for known periods of time, and precise measurements will be made of the damage done. The data obtained will then be used in models to: a) describe changes of outdoor exposure with time and location, b) quantitatively describe degradation processes, c) relate physical changes in the material to chemical changes, and d) relate degradation in outdoor exposures to that in laboratory tests.



Mr. Ned Embree and Mr. Roy McLane install the first temperature/humidity environmental chamber into a BFRL-developed integrating sphere making it possible to control the temperature and humidity, as well as the spectral ultraviolet flux to which polymeric construction specimens are subjected.

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Characterization of Polymer Surfaces

The objectives of this project, led by Dr. Mark VanLandingham, are to develop measurement techniques for evaluating surface mechanical properties of polymeric materials as a function of time and loading rate, to relate material properties to deformation behavior under complex stress states, and to assess the impact of surface deformation on appearance. The project is a contribution to a government-industry consortium led jointly by BFRL, the NIST Materials Science and Engineering Laboratory, and the NIST Chemical Science and Technology Laboratory. Preliminary results have shown the feasibility of mechanical property measurements on polymeric materials using depth-sensing indentation using nanoindentation; they have also shown, for the first time, that a clear relationship exists between material microstructure and appearance. It is expected that this project will lead to the establishment of relationships among mar resistance, appearance, and service life.

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Service Life Predictions for Building Joint Sealants

Buildings rely heavily on joint sealant materials to provide waterproofing and moisture barrier protection. This project, led by Dr. Christopher White, recognizes that in a recent annual survey of homeowners the second-most-cited complaint was water leaking into their homes and, from other studies, it is known that building joint sealants carrying warranties for 30 years or more frequently fail at much shorter times. In spite of the importance of joint sealants in the performance of building envelopes, quantitative information on factors affecting their service lives is not available. The objective of the project is to meet this need for information by developing methods for predicting the service lives of building joint sealants and by suggesting how the information should be made available to those who need it. An instrument to mechanically cycle joint sealant specimens at programmed rates and amplitudes, and monitor their performance under controlled environmental conditions has been constructed. Equipment for automated analysis of chemical changes in the joint sealants has been assembled, and will be used in a government-industry consortium that will become operational in November 2001.

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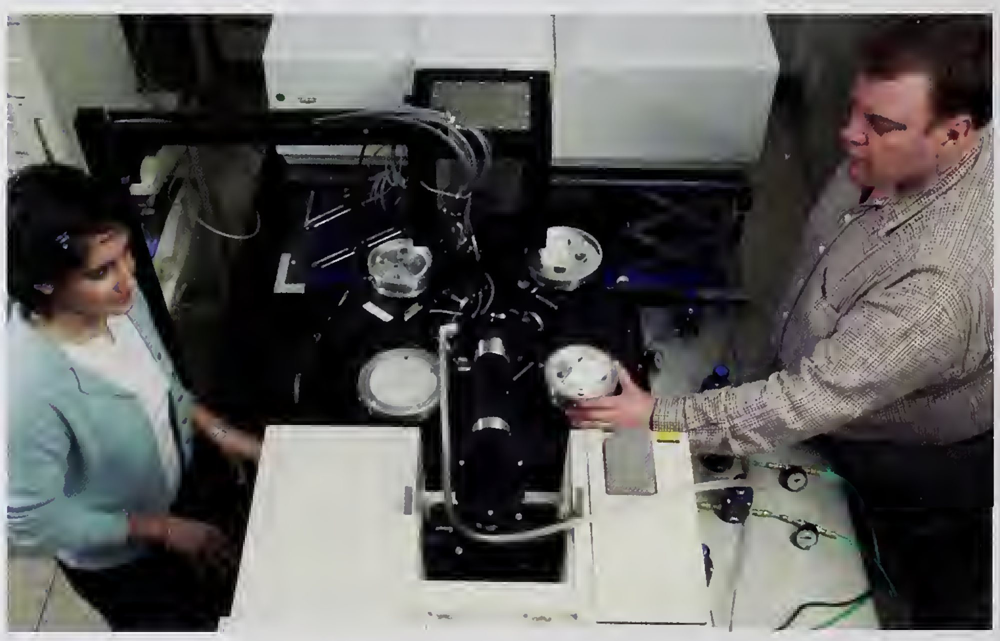

Dr. Christopher White and Ms. Mona Baghai Anaraki, a student, are working on the high-throughput analysis device for characterizing optical, chemical and physical degradation changes in polymeric construction materials. At present, the device can automatically make 9 analytical measurements on each of 70 specimens in one hour. This data is then automatically and electronically downloaded to an informatics system for further analysis.

Measurement Science for Optical Reflectance and Scattering

This 5-year competence project, led by Dr. Mary McKnight, is a cooperative effort involving the Physics Laboratory, Manufacturing Engineering Laboratory, Information Technology Laboratory and the Building and Fire Research Laboratory. The primary objectives are: a) to develop and validate mathematical models to predict optical scattering from morphology and microstructure coating data, and b) to produce a computer rendering of the appearance of a coated product for two model coating systems. These objectives have been successfully completed. The model systems were specimens of a clear epoxy coating with varying surface roughnesses and a metallic-pigmented coating system with either varying orientations of the flakes or varying flake sizes. New competencies were developed in characterizing the morphology and microstructure of coatings using confocal and scanning white-light interference microscopies, in determining the directional reflectance properties of materials, and in computer rendering.

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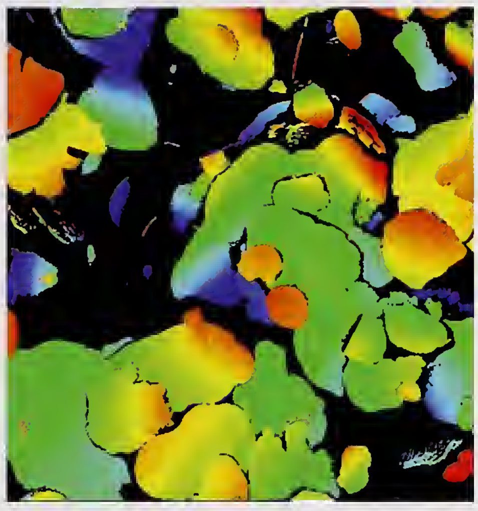
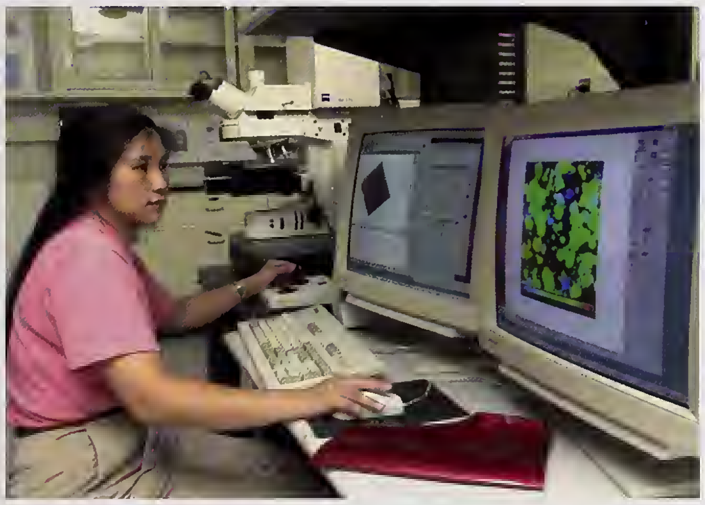


2D projection of a 3D confocal image in which the distance from the bottom surface is mapped in color. The flakes closest to the surface are red.

Vases rendered with two different metallic-flake pigmented coatings. The vase on the left is coated with a material having larger flakes than the one on the right and appears more specular, consistent with reflectance measurements.



Dr. Li Piin Sung using confocal microscope to characterize microstructure of a metallic flake pigmented coating.

The second focus for achieving the goal of High Performance Building Materials is to enable the reliable application of high-performance concrete (HPC) in buildings and the civil infrastructure. HPC refers to any concrete that has desirable performance attributes that cannot be met routinely with traditional materials and traditional processing. Examples are more durable, stronger, tougher, and more-easily-placed concrete. Barriers to full use of HPC include inadequate understanding of performance attributes, a lack of test methods for evaluating performance, a lack of guidelines for practice, and inefficient dissemination of knowledge to potential users.

Partnership for High Performance Concrete Technology (HYPERCON)

INTENDED OUTCOME AND BACKGROUND

To enable the reliable application, by 2005, of high-performance concrete (HPC) in buildings and the civil infrastructure, HYPERCON, a computer-integrated knowledge system, will be developed, and demonstrated in partnership with industry. HYPERCON will incorporate verified multi-attribute models for prediction and optimization of the performance, life-cycle cost, and life-cycle environmental impact of HPC.

Recognition of the advances in concrete technology has led to common use of the term "high-performance concrete" to refer to any concrete that has desirable performance attributes that cannot be met routinely with traditional materials and traditional processing. The national High-Performance Concrete plan produced under BFRL leadership and published by the Civil Engineering Research Foundation (CERF) in 1993 drew attention to opportunities for development of more durable, stronger, tougher, and more-easily-placed concretes, and for an integrated knowledge system to deliver the technology to practice. High-performance concrete (HPC) technology has a potential for contributing to a 20-25% expansion of the $100B/year U.S. concrete construction market. A white paper, developed in partnership with industry, stimulated the American Concrete Institute (ACI) to form the Strategic Development Council (SDC) in 1997 with the goal of encouraging formation of consortia to advance concrete technology. The growth of the SDC, to where it now has about 50 active members, attests to the industry's commitment to the advancement of HPC technology.

The HYPERCON program focuses on advancing concrete technology by developing and fostering application of performance measurements and science-based predictive tools for optimizing production of reliable high-performance concrete and making the knowledge gained available in an effective way. The program is comprised of seven technical themes:

- Development of a Computer-Integrated Knowledge System (CIKS);
- Processing of HPC, (a) Mixing and Flow, (b) Curing Characterization of Concrete and Concrete Materials;
- Simulation of the Performance and Service Life of HPC;
- Fire Performance of High-Strength HPC (HSC);
- Structural Performance of HPC; and
- Economics and Environmental Impact of HPC.

Fire Performance of High-Strength Concrete

While, at normal temperatures, high-strength concrete (HSC) possesses superior engineering properties compared with conventional concretes, this is not true at temperatures encountered in fires. Specifically, compared with conventional concrete, HSC undergoes a larger relative strength loss even at temperatures below 400°C and is susceptible to explosive spalling at temperatures less than 300°C. To provide data to help assess risks to HSC in a fire, Dr. Long Phan is conducting a comprehensive research program that has provided new insights into the heat-induced transformations that occur in fire-exposed HSC. It has made possible quantification of the effects of temperature, test method, and mixture composition on strength degradation and the tendency for explosive spalling. A new strength-temperature relationship for HSC has been developed that will be proposed for standardization. The program is also examining methods to eliminate explosive spalling. Measurements of internal pressure during heating have permitted, for the first time, quantitative assessment of the effectiveness of short, random polypropylene fibers in mitigating the build-up of internal pressure of water vapor that is believed to cause explosive spalling. The data are being used in the modification and validation of material models, such as the existing Portland Cement Association heat-and-mass transport model, for predicting the behavior of HSC when exposed to fire.

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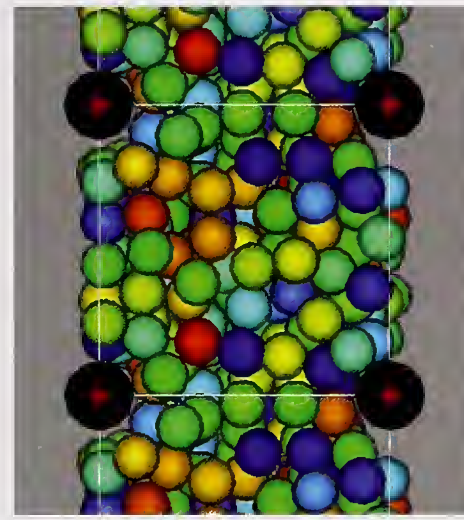
Mr. Frank Davis and Dr. Long Phan examine a concrete specimen tested at high temperature.



Computer simulation of flow of spherical aggregate between rebars.

Processing of High-Performance Concrete: Measurement of Flow Properties

The rheological properties of fresh concrete—its yield stress and plastic viscosity—are important factors in determining suitability for use in each application. In practice, because of the lack of an adequate standard for measurement of the flow properties, these properties are usually determined by the standard "slump" test, which gives a crude measure of the yield stress, but no information about the plastic viscosity. To provide objective methods for determining the flow properties of fresh concrete, this project, led by Dr. Chiara Ferraris, is developing a dissipative particle dynamics (DPD) model for mortar and concrete, methods of measurement of the rheological properties of cement paste and mortar, and guidelines for optimizing the proportioning and processing of high-performance concrete. The DPD model has been developed by Dr. Nicos Martys. In addition, during the year, a round robin intercomparison of five existing types of concrete rheometers was carried out under the auspices of the ACI Subcommittee 236A Fresh Concrete Workability (that Dr. Ferraris chairs) with financial support from ACI's Concrete Research Council and industry. The intercomparison was performed at the Laboratoire Centrale des Ponts et Chaussees in Nantes, France, in October 2000. Each of the five instruments gave the same ranking for the concretes tested, but the absolute values were not identical. A further step in the intercomparison will be carried out in the U.S. in 2002 and the DPD model will be applied to simulating the flow in the various rheometers to seek to account for differences between results obtained with the different instruments. This study should lead to more widespread use of concrete rheometers in the field, thereby aiding the multi-attribute optimization of high-performance concretes.

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Virtual Cement and Concrete Testing Laboratory

Optimization of concrete is a labor-intensive, time-consuming, and costly process because of the variability of the starting materials and the current practice of basing concrete formulations on measurements of 28-day strength. This project, led by Mr. Dale Bentz, is intended to develop a virtual cement and concrete testing laboratory (VCCTL) as a tool to reduce the number of physical concrete tests needed in the thousands of cement and concrete testing laboratories. Applications envisaged include research and development, mixture proportioning and optimization, and troubleshooting. Version 1.0 of the VCCTL software was installed on the Internet following publication of a VCCTL user's guide. Numerous researchers from around the world have accessed and used the software during the past year. A VCCTL Consortium was established in January, 2001, with the initial participants being six industrial organizations and three NIST laboratories. Initial research topics of the consortium are: 1) enhancement of the cement hydration model to predict pore solution composition and incorporation of the chemical reactions for slag and limestone additions to portland cement, 2) prediction of the rheological properties of fresh concrete, including the effects of air entrainment, and 3) prediction of the elastic moduli of cement paste, mortar and concrete. Significant progress has been made in each of these three areas.

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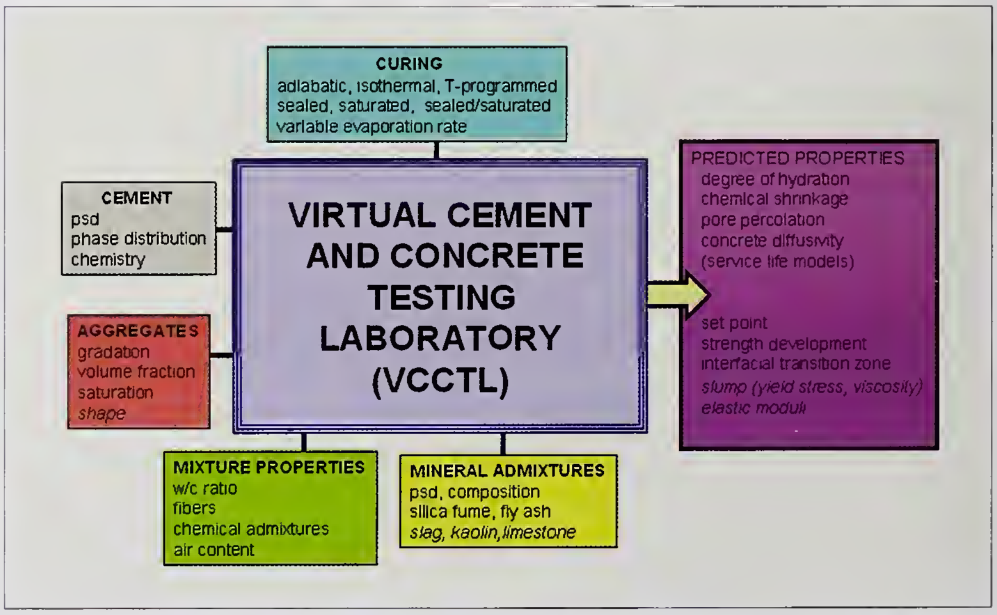
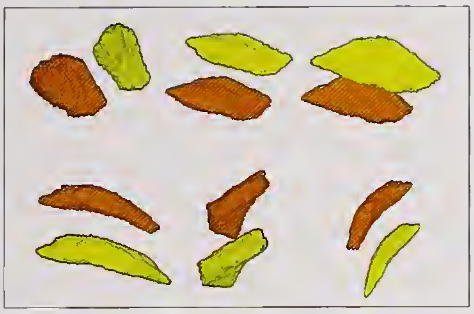


A schematic diagram of how the Virtual Cement and Concrete Testing Laboratory (VCCTL) works. The small boxes to the left represent the information from the well-characterized starting materials that are input to the VCCTL, and the broad arrow to the right represents the results of the various sophisticated computer models that make up the core of the VCCTL.



Six views, from various rotation angles, of a real aggregate particle taken from an x-ray tomographic image (orange), and the same particle, re-created using spherical harmonic analysis (yellow). The mathematical analysis correctly captures the real three-dimensional shape of the irregular aggregate particle.

Application of X-Ray Tomography to Determine Sizes and Shapes of Aggregate Particles.

The rheological and mechanical properties of concrete are determined by many factors including the sizes and shapes of the aggregate particles. In the past, there have not been precise methods for determining these characteristics of aggregates. Now, Dr. Edward Garboczi has shown how to analyze data obtained by X-ray tomography using a spherical harmonic mathematical approach to obtain the desired information on the sizes and shapes. The tomographic data was provided by the Federal Highway Administration (FHWA) in a collaborative effort. The new mathematical analysis technique should eventually make possible the selection of aggregates of the optimal size and shape distributions for a given application in high-performance concrete by investigating the effects of incorporating mathematically characterized real aggregates in various concrete models. The data from this study will be used with the dissipative particle dynamics (DPD) model to predict concrete flow properties. It will also be used to predict properties of hardened concrete and will be incorporated in the VCCTL software mentioned above.

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Economics of High-Performance Concrete

Higher strength and higher durability concrete mixes, when compared with conventional mixes, have the potential to reduce significantly the first costs and maintenance costs of large infrastructures. In a study of high-performance concrete bridges, Dr. Mark Ehlen found these structures to save over $100,000 in life-cycle costs when compared with comparable conventional-concrete structures. To help engineers, designers, and analysts estimate these potential savings, Dr. Ehlen and Ms. Amy Rushing have integrated the BFRL concrete chloride attack, sulfate attack and freeze-thaw models into BridgeLCC 2.0, life-cycle costing software for highway bridges. This software is based on ASTM E 917 standard practice for measuring life-cycle costs, and includes comprehensive sensitivity analysis and Monte Carlo analysis routines, which allow designers to investigate the effects of uncertainty in concrete performance on life-cycle costs.

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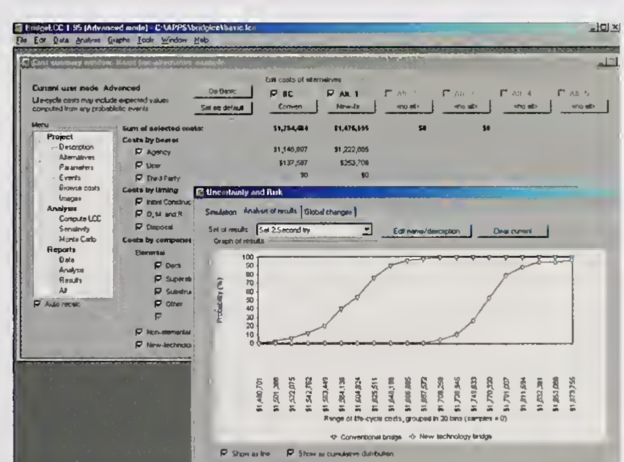
BridgeLCC 2.0 allows for comprehensive probabilistic life-cycle cost analysis of bridges made of high-performance concrete and other materials.



ENHANCED BUILDING PERFORMANCE

To provide the means to assure buildings work (better) throughout their useful lives.

The strategy for meeting this goal is to provide knowledge, measurements and tools to optimize building life cycle performance.

The first strategic focus to achieve the goal of Enhanced Building Performance is to develop measurement methods, fundamental data, simulation models, and life cycle environmental and economic analysis tools to support the wide-spread use of sustainability in design, construction, operation, and demolition of buildings and their systems/subsystems.

Healthy and Sustainable Buildings

INTENDED OUTCOME AND BACKGROUND

The intended outcome of the healthy and sustainable buildings program is to make available measurement methods, test methods, fundamental data, simulation models, and life cycle environmental and economic analysis tools to support healthy buildings, and the wide-spread use of sustainability in design, construction, and operation of buildings and their systems/subsystems.

Global climate change is considered by many as one of the most pressing challenges of the 21st century. Scientific opinion on this matter varies significantly, from the view that contributions to global warming are negligible, to the view that man-made carbon emissions are a disaster in progress, requiring immediate substantial reductions in the emission of the so-called greenhouse gases, principally carbon dioxide.

The purpose of the International Climate Change Conference, held in Kyoto, Japan in 1997, was to accelerate the pace of international action on climate change. If adopted by the U.S., the legally binding international protocol would translate for the U.S. into a 7% reduction in 1990 levels of carbon emissions by 2010. The U.S. building sector shares almost equally with the industrial sector and transportation sector in such emissions.

Beyond regulated carbon emissions, the "green movement" is sweeping the building industry. All major building product companies, building designers, and building operators need measurement methods, test methods, fundamental data, and life cycle environmental and economic analysis tools to promote their approaches and products to achieve sustainability.

BFRL will apply its expertise in refrigeration systems, thermal insulation, building integrated photovoltaic systems, indoor air quality, and life cycle economic and environmental analysis methods to promote healthy and sustainable residential and commercial buildings.

BFRL's research on Healthy and Sustainable Buildings will produce a wide range of data, measurement methods, test methods, simulation models and analysis tools that will assist the U.S. in this "transition towards sustainability". These BFRL "products" include:

- Building for Environmental and Economic Sustainability software (BEES);
- performance data on flammable and natural refrigerants;
- artificial intelligence-aided design procedures for refrigeration heat exchangers, new apparatuses/test methods/standard materials for advanced thermal insulation/low temperature insulation/high temperature insulation;
- validated design models for building integrated photovoltaic systems;
- contaminant-based design procedures for predicting indoor air quality; and
- new/revised test methods and rating procedures for evaluating the energy performance of residential and commercial appliances and products.

Efficient Lubricants for Refrigeration and Air-Conditioning

Lubricants are essential in virtually all modern refrigeration systems, yet their role as potential heat-transfer enhancers is not understood and thus not exploited. The refrigeration industry selects lubricants based solely on lubrication characteristics required by the compressor. In most situations, lubricants selected this way cause a degradation of heat transfer and system efficiency. But with the proper choice of the lubricant, a significant enhancement of heat transfer and efficiency is possible.

The goal of the refrigerant/lubricant heat transfer project is to develop tools to enable the U.S. refrigeration and air-conditioning industry to design or to use lubricants that enhance boiling heat transfer which in turn increase efficiency and/or reduce capital costs. Toward achieving this goal, BFRL's Dr. Mark Kedzierski has developed a unique fluorescence measurement technique that is being used to gain fundamental understanding of the phase-change mechanisms of refrigerant/lubricant mixtures. The BFRL/Department of Energy(DOE) fluorescence spectroscopy project has brought together expertise across NIST from process analytical chemistry, fluid properties, optical analysis, and heat transfer. The fluorescence measurement technique relies on the fluorescent properties of the lubricant to measure the mass of lubricant that has accumulated on the surface as induced by the heat transfer. The properties of the lubricant that has accumulated on the evaporator surface closely influence refrigerant heat transfer, system performance and efficiency. Consequently, the research is designed to benefit the refrigeration and air-conditioning industry by unraveling the processes that connect the excess layer to the bulk fluid and its properties and, in this way, establishing a fundamental understanding of refrigerant and lubricant interaction in refrigerant boiling.

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Fluorescence measurement technique being used to gain fundamental understanding of the phase-change mechanisms of refrigerant/lubricant mixtures.

Building Integrated Photovoltaic Test Bed

Residential and commercial buildings consume more than two-thirds of the electricity in the United States. The incorporation of photovoltaics into buildings, referred to as building integrated photovoltaics (BIPV) offers an aesthetically pleasing means of displacing centrally located utility generated power with distributed renewable energy. Building integrated photovoltaics replace conventional building elements such as roof tiles, asphalt shingles, façade elements, and shading devices with photovoltaic modules that perform the same functions but also provide electrical power.

To enable building owners, designers, and architects to make informed economic decisions regarding the use of building integrated photovoltaics, accurate predictive tools and performance data are needed. To address this need, BFRL has installed a building integrated photovoltaic test bed that is located on the south wall of NIST's Building Research Laboratory. This test bed incorporates photovoltaic panels that would

NIST's Building Integrated Photovoltaic Test Bed.

replace the exterior façade of a commercial or office building. The initial configuration of this test bed incorporates four different photovoltaic cell technologies – crystalline, polycrystalline, silicon film, and triple junction amorphous. Each cell technology is represented by two panels within the test bed – one without any thermal insulation behind it – representative of widow and skylight applications – and one insulated to simulate opaque wall applications.

The energy produced by each of these panels and the coincident meteorological conditions are recorded every 5 minutes for a year. The resulting data is being used to improve computer simulation tools that predict the performance of BIPV for various geographic locations and building orientations.

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Multizone Modeling Website Developed

The Building and Fire Research Laboratory has recently developed a website to foster the development and facilitate the application of multizone ventilation and indoor environmental modeling in the areas of building design, operation, maintenance, investigation and research. The website currently provides software tools for performing multizone analysis, information on the applications of multizone modeling, multizone modeling case studies and references to multizone modeling publications. The central feature of the site, the multizone-modeling tool CONTAMW, developed by BFRL's Indoor Air Quality and Ventilation Group, has been downloaded by an average of 80 people per month since it became available in June of 2000. The audience for the CONTAMW program and the website include building designers, manufacturers of HVAC and other building products, IAQ diagnosticians and researchers. Future plans for the website, include the addition of input data for use in modeling analyses, software tools to support modeling efforts, and descriptions of new applications and case studies. The website, documented in a NIST report NISTIR 6728, is *www.bfrl.nist.gov/IAQanalysis*.

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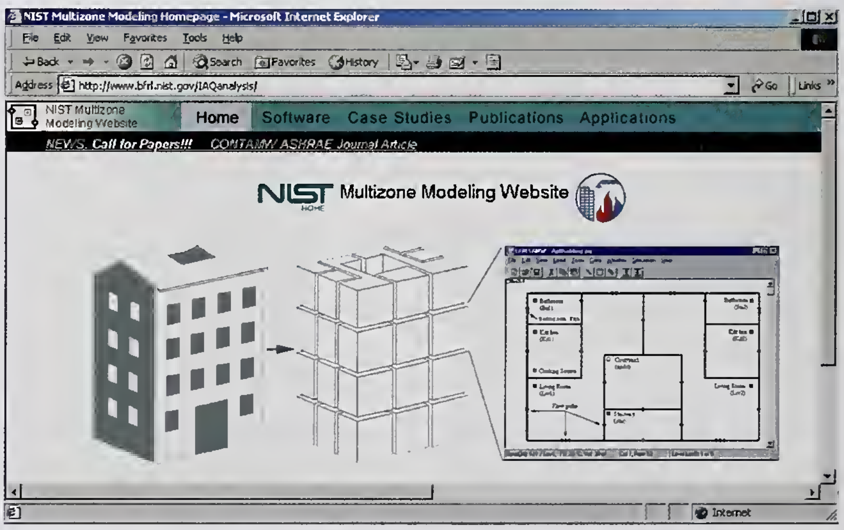


NIST's CONTAMW web site.

The second strategic focus for achieving Enhanced Building Performance is to develop, test, integrate, and demonstrate open Cybernetic Building Systems. The word "cybernetics" comes from the Greek work "steersman" and is defined as the science of control and communication of complex systems. A Cybernetic Building System involves energy management, fire detection, security, transport systems, energy providers, one or more utilities, an aggregator, numerous service providers, and information handling and complex control at many different levels.

Cybernetic Building Systems

INTENDED OUTCOME AND BACKGROUND

The intended outcome of the Cybernetic Buildings Program is to make available tested and demonstrated open Cybernetic Building Systems for improved productivity, life cycle cost savings, energy conservation, improved occupant satisfaction and market leadership. This work will be carried out in close cooperation with the U.S. building industry, industrial partners, building owners/ operators and newly developing service companies.

During the next ten years, the building controls industry in the United States will be undergoing a radical change from one with a vertical structure to one with a horizontal structure. Building control companies, equipment and system manufacturers, energy providers, utilities, and design engineers will be under increasing pressure to improve performance and reduce costs. Cost reduction can be achieved by developing Cybernetic Building Systems that integrate more and more building services, including energy management, fire and security, transportation, fault detection and diagnostics, optimal control, the real time purchase of electricity and the aggregation of building stock.

A Cybernetic Building System involves energy management, fire detection, security and transport systems, energy providers, one or more utilities, an aggregator, numerous service providers, and information handling and complex control at many different levels.

The BFRL program, which will include a full-scale demonstration of one or more Cybernetic Building Systems, will involve the following tasks:

- develop standard communication protocols;
- develop enabling technologies, such as fault detection and diagnostic (FDD) methods;
- develop advanced measurement technologies, including smart multi-functional sensors;
- develop performance evaluation tools;
- develop a standard based program infrastructure supporting the design, commissioning, operation and maintenance of heating, ventilation, air-conditioning and refrigeration systems;
- construct a Virtual Cybernetic Building System in the laboratory to facilitate the development and evaluation of new products and systems by manufacturers;
- conduct basic research on the dynamic interactions of a fire, HVAC/distribution and the zones of a commercial building through utilization of existing and new simulation models, and validate this new simulation program through both laboratory and field studies;
- develop a consortium of manufacturers and service providers interested in producing, testing, demonstrating and selling Cybernetic Building Systems;
- test and evaluate different security concepts and supervisory security systems for the critical infrastructure protection of integrated building systems; and
- conduct a full-scale demonstration of a Cybernetic Building System in a government owned office building complex.

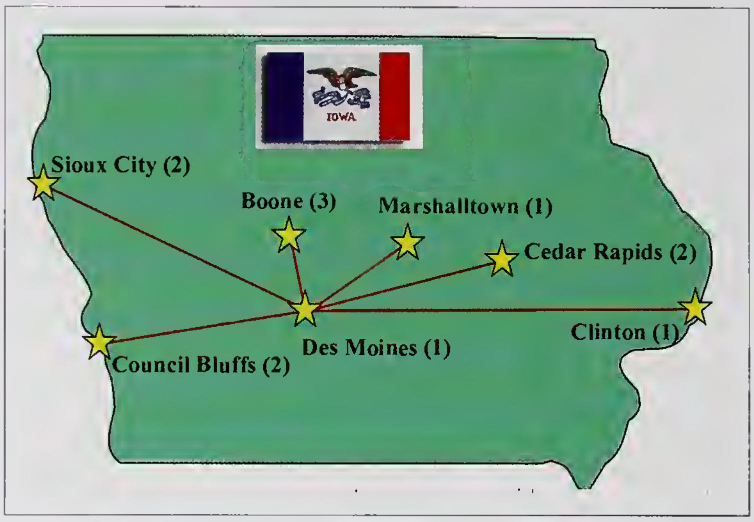
ACCOMPLISHMENTS

BACnet Demonstration in Iowa

BFRL is working with the State of Iowa and the National Guard Bureau to demonstrate the benefits of BACnet™ technology for integrating building control systems over a wide area network. The Iowa Army National Guard (IA-ARNG) Smart Building Demonstration Project links 12 buildings in 7 different cities across the Hawkeye State using building control products from five different manufacturers.

The objectives of the project are to:

- assist the IA-ARNG in meeting its energy and water conservation goals;
- monitor energy consumption and system alarms from a central site;
- improve maintenance by providing facilities staff with effective tools that can access all of the buildings from any site in the state; and
- to reduce overall facilities management cost.



The IA-ARNG Smart Building Demonstration Project links 12 buildings in 7 cities using BACnet control products from 5 different manufacturers.

Like the National Guard in most states, Iowa does not have enough staff to maintain facilities experts at each site, and building systems are not well controlled to maintain comfort conditions while minimizing energy costs. BACnet is a standard communication protocol (ANSI/ASHRAE Standard 135-1995) developed by BFRL and industry experts that provides a way to integrate building control products made by different manufacturers. Using BACnet allows the IA-ARNG to simultaneously improve building control, reduce energy costs, integrate facilities state-wide, and procure building control products using a competitive process that lowers cost.

In addition to working with industry to develop and maintain the BACnet standard, BFRL researchers developed an integration plan for the IA-ARNG and are providing technical assistance for design, installation, and operation of the state-wide BACnet network.

The project is funded by National Guard Bureau and is expected to influence the practices and policies for the use of building control systems throughout the U.S. military.

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Model-based FDD Tool for Chillers

Detecting degradation faults in vapor compression systems remains a challenge in spite of the advances in monitoring and controls software. Basic monitoring equipment can be used to detect the most obvious faults. However, degradation faults can have a small effect on the system's ability to control building conditions and occupant's comfort while having a large effect on energy consumption and expected equipment life. NIST has conducted research in this area with the aim of developing a fault detection and diagnostic method that can be embedded as software in a building energy management system (BEMS) and enable it to identify typical and costly system faults, generating warning alarms if the system performance begins to degrade.

NIST has developed a model-based approach to fault detection and diagnostics for a reciprocating chiller and examined the performance of the method using simulation and experimental data. MATCH (model-based assessment tool for chillers), the implementation of the classifier and expert rule set in the software, was first applied to fault-free and faulty experimental data using 7 performance indices. As expected, the ability to detect faults is influenced by the severity of the fault and the operating conditions. MATCH successfully detected and diagnosed condenser fouling, refrigerant undercharge, and refrigerant overcharge at a fault level of 20% or greater and evaporator fouling and liquid line restriction at a fault level of 30% or greater. Published results are scheduled to appear in the ASHRAE Transactions, 2002.

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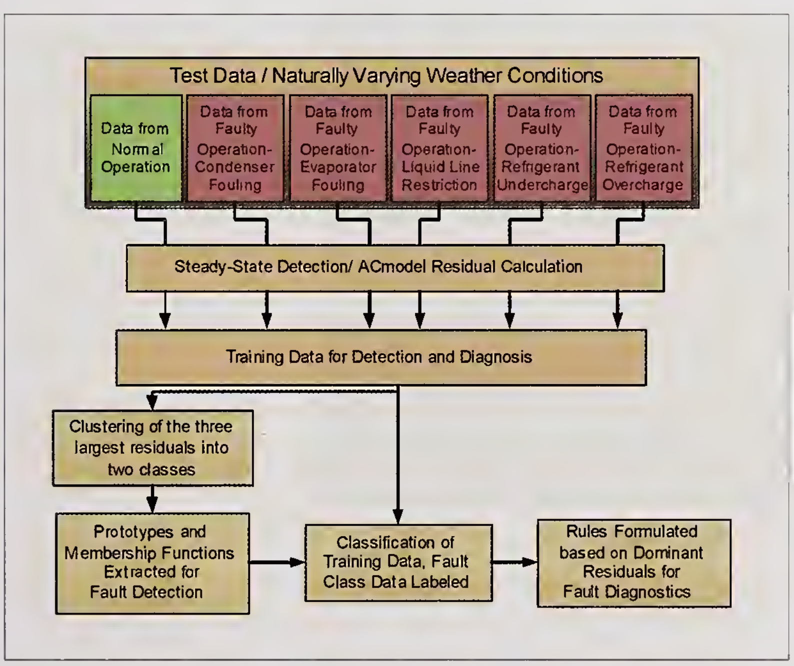
Development of a Model-based Assessment Tool for Chillers (MATCH).



The Virtual Cybernetic Building Testbed

The Virtual Cybernetic Building Testbed (VCBT) is a real-time emulator consisting of state-of-the-art BACnet speaking control systems interfaced with simulation models running over a network. BFRL researchers, control systems manufacturers, service companies, and software developers can use this unique hybrid software/hardware testbed to develop and evaluate control strategies and products. The VCBT is able to emulate three modes of building operation: normal operations, fault conditions, and emergency conditions such as a fire or hazardous materials release.

The VCBT models a three-story building including a variable air volume (VAV) HVAC mechanical system, the indoor building environment, a building shell model and heat sensors for detecting fires. Each floor is served by an independent air handling unit (AHU). Controllers for the AHUs and VAV boxes are supplied by several different manufacturers. The VCBT is capable of simulating a fire in the building. The simulation components may each run on different computers, passing data to each other through the use of a central communications and management component. The communications infrastructure is provided by the Common Object Request Broker Architecture (CORBA). A sophisticated user interface was created using Virtual Reality Modeling Language (VRML).

The VCBT has the capability to reliably produce simulated mechanical system faults and outdoor weather conditions, and is being used to test prototype tools for detecting common faults in HVAC mechanical systems. It is also being used to develop a sensor-driven fire model for the next generation of smart fire panels that can predict how a fire will grow and spread in the building.

Planned future enhancements include adding central plant and lighting controls, and developing a more flexible and sophisticated VCBT building modeling scheme using product data information represented by Industry Foundation Classes (IFCs).

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Virtual Cybernetic Building Testbed Control System Hardware.

Sensor-Driven Fire Model

The Sensor-Driven Fire Model (SDFM), currently under development at NIST, is designed to use signals from building sensors to predict the size and growth of fires in buildings. Algorithms have been developed that use the signals from heat, smoke, or gas sensors to determine the Heat Release Rate (HRR) or fire size in each room. Based on the HRR of each fire, the SDFM then predicts the temperature, smoke and gas concentrations, and smoke layer heights in all rooms of the building. With these predictions, an overview of the current fire situation in a building can be transmitted to the fire service. The SDFM is being tested using the Virtual Cybernetic Building Testbed (VCBT). The VCBT provides a simulation of a multi-room building where fires are simulated using the fire model CFAST. Additional testing will be done using fire experiments such as the one shown on the following page.

Algorithms are being developed for use in the SDFM to discriminate between fire and nuisance sources. Testing of these algorithms will be accomplished using the Fire Detection Laboratory (FDL) at NIST. The FDL is equipped with ceiling mounted heat,

Typical fire experiment used to test the SDFM.

smoke and gas detectors that are designed to investigate the response of detectors to small fires and nuisance signals. Signals from both nuisance sources and fire sources will be transmitted from the FDL to the SDFM through the VCBT. The object of these experiments will be to determine a nuisance signal rejection rate for the SDFM. Additional information is available about the SDFM from the publication "A Sensor-Driven Fire Model Version 1.1," NISTIR 6705.

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The third strategic focus for achieving the goal of enhanced building performance is to optimize building life cycle performance.

Optimized Building Life Cycle Performance

INTENDED OUTCOME AND BACKGROUND

The intended outcome of the Optimized Building Life Cycle Performance program is to develop, implement, test, demonstrate and standardize an integrated information-simulation infrastructure for optimizing the life-cycle performance of commercial buildings and enabling effective decision support throughout the entire life cycle. This work will be carried out with academic and industry partners and will focus on both predicting life-cycle performance and on enabling the automation and integration of building processes and services across life-cycle phases.

Today there is a desperate need within the building industry for:

- **standardized models and protocols for representing and exchanging information and knowledge on building, building systems and equipment, control and operating procedures, expected performance, commissioning-operation-maintenance-security requirements and practices, and internal and external services;**
- **credible performance predictive models and tools that will allow users to compare and optimize on a life-cycle basis alternative designs, products, operation and maintenance practices, and services; and**
- **standardized information-simulation infrastructure that will tie all these information-simulation requirements together.**

ACCOMPLISHMENTS

This is a new program starting in FY 2002.

FIRE LOSS REDUCTION

To enable engineered fire safety for people, products, facilities and enhanced firefighter effectiveness.

The strategy to meet this goal is to reduce the risk of flashover in buildings, to advance fire service technologies, and to make advanced measurements and develop predictive methods.

The first element, reducing the risk of flashover, is a key factor in reducing fire deaths.

Reduced Risk of Flashover

INTENDED OUTCOME AND BACKGROUND

The intended outcome of this program is to eliminate the risk of flashover cost-effectively by enabling: new/improved materials whose fire resistance does not negatively impact performance, cost, or the environment; and early and certain fire and environment sensing and automatic fire suppression technologies compatible with occupants and the environment.

Flashover is the dramatic and sudden transition from a relatively small, slowly developing fire, spreading systematically across adjacent fuel surfaces within a room, to a much larger and dangerous fire in which all flammable surfaces within the enclosure are involved. Estimates based on the extent of fire damage indicate that the roughly 30% of reported fires that transitioned to flashover were responsible for 80% of the fires deaths and property damage in buildings during 1999. Clearly, reducing the risk of flashover offers an opportunity to reduce significantly the high human and property costs of fire to the Nation.

Reducing the risk of flashover can be equated with reducing fire spread, fire growth, and the maximum value of the heat release rate. There are two general approaches for accomplishing these goals. The first is to limit the availability of fuel (e.g., though the use of fire-retarded fuels) and air (e.g., by controlling ventilation) such that a fire cannot become sufficiently intense to induce flashover. The second is to provide physical intervention (e.g., through automatic sprinklers, or by a fire company following early detection) to reduce the fire size before it can grow to a dangerous level. Both approaches are important and will be included in this program.

Experimental and theoretical understanding of fire growth and spread within enclosures will be improved, with the goal of developing a modeling capability for real-world room contents that can be reliably used for fire safety engineering, product design, and materials assessment.

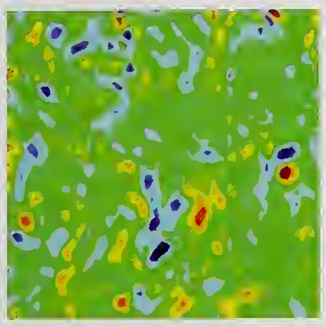
BFRL will develop cost-effective approaches that reduce the flammability of polymers while maintaining or even improving their physical characteristics. Success in this approach will provide a strong incentive for polymer producers and product manufacturers to utilize these safer materials in commodity applications.

Active measures to limit fire growth require reliable early fire detection and effective suppression approaches. Directed research designed to enhance fire detector sensitivity while reducing the number of false alarms and to improve suppression effectiveness will be carried out.

ACCOMPLISHMENTS

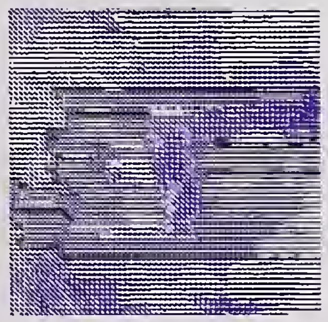
Particle Image Velocimetry Provides Improved Measurements of Fire-induced Doorway Flow

Flashover represents a substantial upward jump in the hazard presented by a room fire and the potential for further fire loss. As flashover approaches, there is a transition toward control of the rate of burning by the oxygen supply available through room surface openings. BFRL is seeking to quantify the rate of gas flow through room surface openings, specifically doorways, with a higher accuracy than has been the case in the past. Particle Image Velocimetry (PIV) is a non-intrusive laser-based measurement technique that is being applied to measure two-dimensional fields of velocity vectors in the lower layer of a fire-induced doorway flow. The technique significantly improves upon the spatial and temporal resolution of traditional bi-directional probe measurements. It also offers at least 2 orders of magnitude increase in the amount of data available when compared to a traditional probe array.



Instantaneous vorticity field.

Mean Flow Streamlines.



Instantaneous velocity field.

The present challenges of the technique are associated with illuminating and seeding a large spatial region such as a doorway.

The first year of the project resulted in the design and demonstration of a particle distribution system. It was demonstrated, at a slightly reduced-scale, in an isothermal flow that simulated the conditions of large fire experiments. Two-dimensional images of gas velocity vectors were recorded using the PIV technique for a 26cm x 26cm region along the axis of a surface opening. The figures included display samples of the instantaneous velocity field, instantaneous vorticity field, and mean flow streamlines, respectively. The measurement location was the vertical plane perpendicular to the doorway plane and vertically centered at the intersection of the vertical and horizontal axis of the doorway for a small enclosure. The flow direction was left-to-right and into the enclosure. The two-dimensional instantaneous images demonstrate that flow direction and flow rotational structure can be realized, which is another improvement over probe measurements. Current efforts focus on increasing the measurement region to 100cm x 100cm and adding a buoyant source to better simulate fire conditions and characterizing the resulting flow field.

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Bench-Scale, High Throughput Flame Retardancy Measures

Current methods used to study the flammability properties of materials focus on individual sample compositions or "one-at-a-time" methods for each set of experiments. New "high throughput" approaches to knowledge discovery in a variety of other scientific fields (chemical catalysis, drug discovery) have demonstrated an order-of-magnitude greater rate of technology discovery and a 50 % faster time to complete implementation of the technology. The number of important material and engineering parameters associated with fire retardant products is large (>10), and the number of permutations within each parameter is also large (5-10). Furthermore, the number of application specific performance properties is large (5-10). Consequently, millions of experiments and measurements need to be done to build a reasonable understanding of the fundamental issues controlling the performance of flame retardant materials. To meet this challenge we are developing high-throughput flammability characterization methods.

We have developed the composition-spread or gradient approach. These samples essentially represent a range of samples within one gradient sample. We have optimized the extrusion of gradient samples with continuously varying concentrations of additives using a computer-controlled gravimetric-fed twin-screw extruder. A model flame retardant

Computer-controlled gravimetric-fed twin-screw extruder used to optimize the extrusion of gradient samples with continuously varying concentrations of additives.

system (ammonium polyphosphate (APP), pentaerythretol (PER), in polystyrene (PS)) was extruded into gradient slab-shaped samples. These were characterized off-line using automated-thermogravimetric analysis (TGA), and high throughput x-ray absorption (XRA), to determine the gradient of additives within the extruded samples. We are in the process of developing online characterization methods of the gradients as they are formed using fiber-optically coupled Fourier Transform Infrared (FTIR), and visible spectroscopy (Vis). Special cells for these devices will be built and installed on the extruder. The feasibility of characterizing the flammability properties of the gradient samples will be done using several approaches:

- evaluation of self-extinguishing behavior and upward flame spread of the gradient samples in a UL94 test chamber;
- evaluation of ignition properties using the horizontal ignition and flame test apparatus; and
- evaluation of pyrolysis properties using the radiative gasification apparatus.

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Smoke Alarm Performance Measured in Residential Buildings

Smoke alarms are often the primary life safety strategy for occupants in the event of an unwanted residential fire. As the number of residential fire deaths (about 3000) far outpaces the number of commercial and industrial fire deaths (just over 100 in all non-residential structure fires) it is crucial to understand the level of safety provided by smoke alarms in the residential environment. With funding from a consortium of government agencies and private sources of more than $1 million, BFRL researchers are evaluating the current state of residential smoke alarm requirements.

The overall purpose of the project is to determine how different types of fire alarms can respond to threatening residential fire settings in order to permit egress of typical occupants. BFRL is conducting real-scale tests of current smoke alarm and related technologies in actual homes with actual contents as fuels. Fire scenarios (including ignition source, first item ignited, room of origin, time of day and season that affect occupant location and building condition) were selected based upon a statistical analysis of available fire loss data. Selected fires include a mattress fire in a bedroom, an upholstered chair fire in a living area, and a grease fire in a kitchen.

BFRL has completed two series of

Instrumentation for smoke alarm tests in a manufactured home.

Fire in two-story home used to test performance of current smoke alarms.

tests, one in a single-story manufactured home in the NIST fire research test facility and one in a two-story single-family home in Kinston, NC. Test results are available online at *http://smokealarm.nist.gov*. Data presented include CO, CO_2, O_2, smoke obscuration, and temperature. Additional measurement of smoke particle size and concentration, additional gas species, and gas velocities and directions will be included in upcoming reports.

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Technologies for Building Less Flammable Mattresses Assessed

Fires in which bed-clothes or a mattress are the first item ignited result in hundreds of deaths each year in the United States. In an effort to alleviate this problem, the mattress industry is working with NIST on defining the technical parameters of the problem and on assessment methods that will help point the way to assured solutions. The typical bed fire is started by a small flame contacting the bed covers. The bed covers then begin to burn in a manner that becomes a greatly enlarged challenge to the mattress. However, the heat stress they impose on the mattress is highly variable and difficult to reproduce. As a first step in this program, NIST characterized that thermal stress and then developed much more reproducible gas burners to simulate it. These burners have been applied to a range of potentially less flammable mattress designs to assess the most promising available technologies for building less flammable mattresses. NIST is now looking in detail at the hazard represented by a given bed fire size in an attempt to assess the potential for relating fire size reduction to lives that may be saved. This involves looking not only at the bed fire directly but also at the potential of this fire to initiate other nearby fires on other objects in the same room. To enable this NIST has measured the transient heat flux distributions around a wide variety of bed fires burning in isolation and in a compartment. Surrogate materials, representing a variety of other possible flammable objects in proximity to a bed fire, are being characterized for their ease of ignition. The combined impact of a bed fire and a secondary object fire can be judged in the context of Hazard I, a NIST smoke and heat transport model. In a closely related study, NIST is working with the Consumer Products Safety Commission to define a test method by which CPSC will be able to assess the flammability of mattresses purchased on the market. CPSC has announced its intent to consider regulating residential mattress flammability.

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Bed fire about two minutes after ignition with a match sized flame.

The second strategic element in achieving the goal of Fire Loss Reduction is to advance fire service technologies. A key factor in reducing firefighter and building occupant fatalities and burn injuries is to develop advanced technologies for the fire service.

Advanced Fire Service Technologies

INTENDED OUTCOME AND BACKGROUND

The intended outcome of this program is to help achieve a 50% reduction in line-of-duty fatalities and burn injuries in the U.S. by 2012, through the products of research, and to enhance fire fighter safety and effectiveness.

Fire fighting operations, inside and outside of structures, proceed with very limited information about the extent of fire involvement, structure safety, hazards, and even the location of fire fighters. In order to be safer and more effective, incident commanders, and fire fighters need access to reliable and timely information regarding fire conditions, developing hazards, and the location and condition of resources.

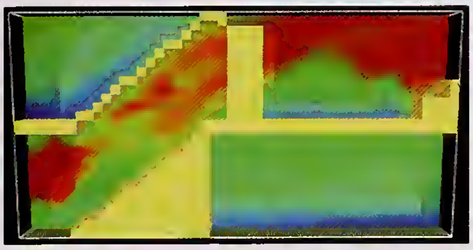
The program includes the following elements:

- **The heat transfer model for fire fighter protective clothing under wet and dry conditions with associated material property database will be advanced by further development of standard measurement methods. This model will be used to generate training tools to allow fire fighters to visualize the limits of performance of their protective gear.**
- **Working with a consortium of fire alarm manufacturers and the laboratory effort in Cybernetic Building Systems, develop a wireless means to deliver timely emergency information about conditions inside of buildings. Predictions of developing hazards to first responders before they arrive at the scene will be demonstrated.**
- **Interacting with the industry, BFRL will focus on expanding the capabilities of thermal imagers for improved sensing for fire hazard and fire rescue applications**
- **A fundamentally based computational model will be developed to predict major features of the interaction of structures with wind-driven fires utilizing the present Fire Dynamics Simulation technology as a starting point.**
- **Through a university grant, the capabilities of acoustic sensing to determine weakness in roof structures will be explored.**
- **Nano-particles added to polymer gels used to protect external structures against fire have been shown in laboratory scale experiments to greatly increase the durability of the gel. A standard method to determine the performance in full scale will be investigated to allow durable agents with different nano-particle formulations to be evaluated.**
- **To aid the fire services in keeping abreast of developments in research activities around the world, information about fire service related research will be collected and distributed by electronic means.**

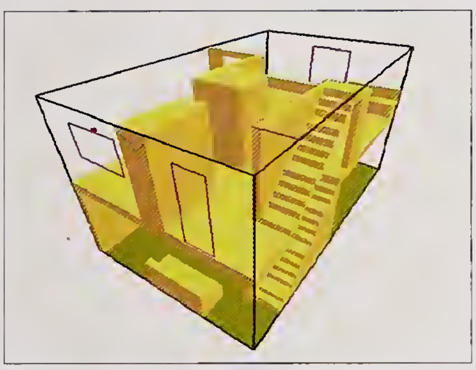
ACCOMPLISHMENTS

Cherry Road Simulation CD

NISTIR 6510, includes a re-creation of a multiple fatality fire, which occurred at 3146 Cherry Road, Washington D.C. on May 30, 1999. At the request of the District of Columbia Fire & Emergency Medical Services Department Reconstruction Committee, a team from BFRL visited the fire scene, documented critical dimensions, and collected samples for additional materials property characterization. After entering the dimensions and material thermal properties into the Fire Dynamic Simulator model, the team utilized Smokeview software to display the model simulation for the investigating



Computer simulation of the Cherry Road fire.



Representation of the Cherry Road residence using Smokeview.

committee. As the reconstruction committee combined the model output with the fire service timeline and other fire ground data, the investigators were better able to understand the fire behavior and how fire fighter fatalities occurred. The committee asked the NIST team to simulate several alternate "what if ?" scenarios to understand how fire fighters could avoid similar situations in the future. The team packaged still figures and animated images of the simulation with all the timelines, floor plans, and material properties into a single CD, NISTIR 6510. To access the report and view the animations, fire fighters may simply insert the CD into a CD drive and use self-loading software on the CD.

The impact of this fire simulation/re-creation is already evident as fire departments have requested over 7000 copies of the CD since its release last summer. Fire service training instructors are incorporating the simulation into training programs for fire fighters. Fire protection engineers have reviewed the model output, obtained copies of Fire Dynamic Simulator (*http://fire.nist.gov*), and are beginning to use the model to develop more fire safe structures. Fire investigators who have seen the animations have requested the BFRL team to assist with their investigations in numerous fire scene reconstructions, including multiple fatality fires in Keokuk, IA, New York, NY, and Houston, TX.

The NIST Cherry Road Report was the basis of a front page *Washington Post* story, which appeared July 31, 2000. A Discovery Science News piece was developed and has aired. Numerous websites have picked up the report information, these include, *www.firehouse.com*, *www.wp.com*, *www.firefighting.com* and *interfire.org*. EENET, a satellite broadcasting station of the U.S. Federal Emergency Management Administration (FEMA) is in the process of producing a program based on the Cherry Road incident.

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Video on How Fast Fire Spreads

Fire experts know that blazes depicted in movies and TV give the wrong impression about how fast a fire can really grow and how much time is truly available for a person to escape. This misinformation may cause people to underestimate fire dangers and make bad, sometimes tragic, decisions in a real fire situation.

BFRL has assembled a 10-minute video collection of fire taken from recent large-scale tests conducted in BFRL's large fire test facility. The video clearly portrays how fires grow from ignition to flashover in furnished rooms (flashover occurs when all combustibles in a room burst into flames and the fire spreads rapidly). Segments on the video show the ignition and burning of (1) a dry Christmas tree in a living room (flashover in 45 seconds), (2) an upholstered sofa in a living room (flashover in four minutes), and (3) a wastebasket near an office workstation (flashover in about five minutes). Over 3000 copies have now been distributed to fire departments around the world.

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Single-Family Home Fire Experiments Featured in Phoenix Fire Department Training Video on Structural Collapse

During October 2000, a BFRL team of engineers and technicians instrumented and burned four single-family homes in Phoenix, AZ. The Phoenix Fire Department plans to include video and temperature data in a training video to educate fire fighters about the hazards of structural collapse. The BFRL team, headed by Mr. David Stroup, monitored the first floor and attic spaces from ignition through structural collapse. Instrumented mannequins, dressed in full turnout gear with air tanks, kneeling and standing, were placed on the roof of each structure to simulate the static loading of fire fighters on a residential roof. The BFRL team also collected data on related ongoing projects including Fire Dynamics Simulator Model Verifications, Burn Pattern Analysis, Characterization of Thermal Environments, Performance of Thermal Imaging Systems and Protective Turnout Gear for Fire Fighters. The real fire experience of the Phoenix Fire Department and the large-scale fire experiment capabilities of the BFRL team were combined to yield a better understanding of how and when structural collapse occurs during a residential structure burn. This insight and the training video will help improve the safety of fire fighters involved in the suppression of residential fires.

Phoenix Fire Department burn instrumented single family home for training video.

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In-Situ Oil Spill Marshland Burns featured on CNN Earthwatch

In November, 2000, CNN Earthwatch featured interviews and video from a series of crude oil fires conducted to evaluate the impact of intentional burning of crude oil and diesel fuel spilled in a marshland environment. Oil spilled in sensitive wetland environments poses unique problems associated with cleanup because mechanical recovery in wetlands may result in considerable damage to the wetlands. *In situ* burning of oiled wetlands may provide a less damaging alternative than traditional mechanical recovery. In a series of 10 burns, 240 plants were positioned at different soil/water elevations for 700 second exposure to burning crude oil or diesel fuel. CNN filmed the set-up of a burn and the burn itself for its Earthwatch series. Interviews with members of the BFRL team were conducted before and after the burn. Soil, water and air temperatures were monitored throughout each burn exposure and for a 4800 second post-burn period. The soil temperature data will be combined with the plant re-growth and recovery rates to develop guidelines for oil spill

Test burn to study effects of intentional burning of oil spills in marshland environment.

response teams to use when considering in-situ burning as an alternative to mechanical recovery. This project is part of ongoing work funded by the Mineral Management Service, U.S. Department of Interior.

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Fire Research Experiments Featured During Week Long "Fire Dynamics in A Live Burn Situation" Seminar Series

Seven townhouse apartments and six attached rooms were furnished, instrumented, and set on fire in Pinal County, AZ, as part of a seminar series sponsored by the International Association of Arson Investigators. Arson investigators were given the opportunity to view each apartment or room before and after ignition. A film crew from the Bureau of Alcohol, Tobacco, and Firearms (ATF) filmed each of the burns for inclusion in a fire scene re-creation video which will be used as a training tool for arson investigators. Chemists from the Federal Bureau of Investigation (FBI) were on hand to demonstrate proper evidence gathering

Burn of instrumented townhouse for arson investigation study.

techniques. Mr. Dan Madrzykowski and Mr. David Stroup taught sessions on Fire Dynamics and Computer Modeling. The BFRL team also collected data for a number of ongoing research projects including: Personal Alert Safety Systems (PASS) Project, and Improved Fire Safety for Kitchens. These experiments demonstrate NIST's leadership in the field of fire dynamics and large-scale fire experiment capabilities, and enhance the training and education of fire investigators.

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The third strategic element of achieving Fire Loss Reduction is to advance measurement and predictive methods for reducing fire loss. The development of less flammable materials and the design of buildings with improved fire safety requires the development of advanced measurement and predictive methods.

Advanced Measurement and Predictive Methods for Reducing Fire Losses

INTENDED OUTCOME AND BACKGROUND

The intended outcome of this program is to be a world leader in fire measurement and predictive methods, enabling engineered fire safety for people, products, facilities, and first responders. This work underpins the Advanced Fire Service Technologies and Reduced Risk of Flashover programs and will be carried out in close coordination with those programs and their partners.

To preempt the anticipated increase in fire-related deaths and injuries associated with a larger and more aged population, new fire safety technologies and performance-based codes are

needed. These can be achieved only through a higher level of understanding of the dynamics of fire, and more certain measurement methods.

During the next 10 years, the building industry in the United States and the rest of the world will be undergoing a radical change as prescriptive fire codes for built facilities are replaced by performance based codes. BFRL will create the knowledge base to allow the development of accurate and appropriate predictive tools and test methods that will enable the implementation of performance based design of fire protection systems.

Fundamental experiments and analyses will be coordinated with full-scale measurements and data to expand our ability to simulate numerically and visualize real fire phenomena with increasing certainty. Direct numerical simulation and computational fluid dynamic models of transport processes will be further expanded to encompass higher accuracy radiation, droplet and sprays models; and semi-empirical sub-models will be developed of phenomena at the fuel/flame interface and of the condensed phase. New instrumentation and test methods will be developed to support these models, and reference data will be produced as input parameters for the models, against which predictions can be compared at multiple levels: sub-scale, single item response to fire, second item burning, and full scale demonstrations.

The program is organized around four main areas:

- **advanced measurements;**
- **advanced predictive methods;**
- **standards and codes; and**
- **information.**

ACCOMPLISHMENTS

Pollution Abatement System for the Large Fire Laboratory (LFL) Installed

Solid progress has been made to advance measurement capabilities and refurbish/upgrade the Large Fire Laboratory. The pollution abatement system for the Large Fire Laboratory (LFL) has been installed and passed Maryland emission requirements. Equipment for the heat release rate measurements for the 6-m hood has been installed and has been used for measuring heat release for a project involving mattress burns. Velocity and pressure probes have been deployed in and around the LFL for monitoring the velocity field external to the LFL. Progress has been made on both the droplet imaging and the two- dimensional imaging of flow velocity. In the first case, the instrumentation has been assembled and calibration measurements for droplet size have been completed. Two dimensional flow fields have been imaged over a 26 cm x 26 cm area in the vicinity of the opening of an enclosure. An uncertainty analysis has been completed for a widely used radiant

Newly installed pollution abatement system for the Large Fire Laboratory.

heat flux gauge and preliminary results were obtained on the optical properties of soot in the infrared part of the spectrum, which are needed for modeling radiant transport.

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FIREDOC EXPRESS and FASTData Expand Fire Information Dissemination

In FY 01, approximately 2300 articles were added to FIREDOC, the online bibliographic database to the Fire Research Information Services literature collection. Five new customers were signed up to FIREDOC EXPRESS, the system for obtaining articles in FIREDOC by overnight mail. The BFRL 2000 publications CD was released in May 2001. The second version of the FASTData CD was put into review. FASTData 2.0 has 50% more fire tests than version 1.0. A grant was started to further increase the data in FASTData with test data presently only in paper format and develop tools to make use of this data. Templates for a single subject CD were developed. Tools for creating an electronic "report of test" were developed in conjunction with the Home Fire Alarm Project also know as Dunes II.

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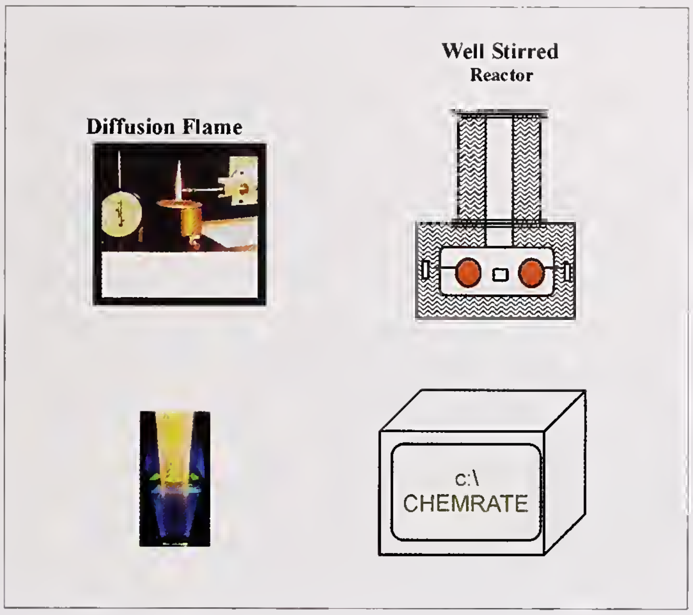

Tools for Developing Data Base for PAH Reaction Rates and Particle Inception.

Data Base for PAH Reaction Rates and Particle Inception being Developed

BFRL is developing a critically evaluated, gas-phase chemical kinetic database describing the transformation of fuel molecules to their desired end products of CO_2 and H_2O and the undesired PAH. The first quantitative soot particle inception model based on experiments is also being developed. The model will streamline the military's particulate mitigation strategies based on computer-based engine design and fuel additive development.

Federal and state environmental agencies have been authorized to regulate the amounts of particulate matter (PM) and PAH emitted from local sources. Military bases and local airports are increasingly being considered point sources of these pollutants and are starting to be held responsible for their particulate and PAH emissions. Additionally, government personnel are constantly exposed to soot particles and PAH emitted from military diesel and gas turbine engines; this is a concern since fine particles are a health hazard and certain PAH are carcinogenic. Motivated by these factors, the military and their engine manufacturers are working to reduce PM and PAH formation in existing and future engines.

The first quantitative kinetic rates for heptyl radical branching have been measured in the effort to generalize combustion models for real fuels. The PAH distribution of early soot has been quantified. New soot sampling methods that can be applied in PAH-laden environments have been developed.

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Fire Hazard Analysis Techniques Developed for Railcars

Mr. Richard Peacock, Mr. Jason Averill, and the Integrated Fire Performance Group are developing advanced fire hazard analysis techniques for application to the fire-safe design of passenger rail and transit vehicles. This effort has included a systematic study of the fire performance characteristics of current rail car materials including characterization of the heat release and smoke production of actual rail car materials in the NIST-developed Cone Calorimeter, full-scale assembly tests of components such as seats and interior panels constructed of these same materials in a furniture calorimeter, and finally real-scale tests of passenger rail cars incorporating the tested components. Comparison of the results of fire hazard analysis of passenger rail vehicles compared to the real-scale test results showed the techniques are capable of predicting times to untenable conditions in the vehicles to within 13 percent. It is expected that this work will lead to the recognition of fire hazard-based methods as an alternative to the current prescriptive requirements for passenger rail and transit vehicles.

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Fire growth in real-scale gas burner fire tests in a passenger rail coach car.

Planar Laser Measurement of Large Scale Sprinkler Flows

The widespread use of advanced computer models for fire environment prediction has been accompanied by the desire for sophisticated modeling of fire suppression. In order to predict multiple sprinkler activation, the interaction of fire plumes and sprinkler sprays, and the suppression of fires by sprinklers, high quality input and validation data are needed. To provide the necessary data, advanced measurement techniques under development at NIST, in cooperation with the University of Michigan, can simultaneously measure droplet size and velocity within large-scale sprinkler flows at scales capable of capturing large-scale unsteady behaviors.

Existing measurement methods are unable to provide instantaneous large-scale measurements of droplet size and velocity. The imaging technique under development provides qualitative and quantitative droplet size and velocity information over an area of 1 m by 1 m in size with low levels of uncertainty. In this technique, water droplets are fluoresced with pulsed laser sheets, and the image recorded by a camera perpendicular to the flow. The measurement method allows for the determination of the velocity distributions of a given size droplet, as well as the mass and momentum fluxes throughout the flow field. The technique is being developed for use in the study of sprinkler flows with the goal of understanding scaling behaviors and providing input and validation data for computational models.

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Impact of Sub Lethal Fire Smoke Estimated

Most U.S. fire deaths and injuries result from smoke inhalation, and thus smoke toxicity is of prime concern to fire safety professionals. However, after more than four decades, there continues to be difficulty and controversy in addressing the contribution of the effects of smoke in fire hazard and risk analyses. Under the sponsorship of the Fire Protection Research Foundation (FPRF), the NIST Fire Research Division (FRD) and the National Fire Protection Association (NFPA) have embarked on a public/private fire research initiative, the "International Study of the Sublethal Effects of Fire Smoke on Survival and Health" to provide scientific information on these effects for public policy makers. FRD fire scientist Dr. Richard Gann leads the effort. The project objectives are: to identify fire scenarios where sublethal exposures to smoke lead to significant harm; compile the best available toxicological data on heat and smoke and their effects on escape and survival, identifying where existing data are insufficient for use in fire hazard analysis; develop a validated method to generate product smoke data; and generate practical guidance for using these data correctly in fire safety decisions.

The first year's effort has produced groundbreaking results:

- the first estimates of the magnitude and impact of sublethal exposures to fire smoke on the U.S. population;
- evaluation of the best available lethal and incapacitating toxic potency values for the smoke from commercial products;
- the first methodology for relating smoke lethal toxic potency data for rats to incapacitation data for people;
- the potential for various sizes of fires to produce smoke yields that could result in sublethal health effects; and
- state-of-the-art information on the production of the condensed components of smoke from fires and their changes during transport from the fire.

These are reported in: Gann, R.G., Averill, J.D., Butler, K, Jones, W.W., Mulholland, G.W., Neviaser, J.L., Ohlemiller, T.J., Peacock, R.D., Reneke, P.A., and Hall, Jr., J.R. "International Study of the Sublethal Effects of Fire Smoke on Survivability and Health (SEFS): Phase I Final Report," NIST Technical Note 1439, National Institute of Standards and Technology, 137 pages (2001); the report can be accessed from the BFRL web site. Articles on these technical findings will comprise a forthcoming issue of *Fire Technology*.

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Through active participation and leadership in many Standards Development Organizations, BFRL staff contributes significant time and technical expertise to the process of developing national and international standards. Standards involvement is listed by organization.

AASHTO

(AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS)

AASHTO Materials Testing Laboratory (AMRL)

Established at NIST (then NBS) in 1965, the AASHTO Materials Reference Laboratory (AMRL) is a research associateship with a staff of 40 that provides a highly-valued quality assurance mechanism for laboratories that use AASHTO standards for highway materials; it also provides technical assistance to the AASHTO Accreditation program (AAP) which currently accredits about 700 laboratories. With Mr. James Pielert as Manager and Mr. Peter Spellerberg as Assistant Manager, the AMRL provides, upon request, as reimbursible services, laboratory inspection and proficiency sample programs. In 2001, over 1000 laboratories participated in AMRL programs. For those laboratories that wish to participate in the AAP, results of the relevant laboratory inspections carried out by the AMRL and the ASTM-sponsored Cement and Concrete Reference Laboratory (CCRL) are the basis for accreditation. AMRL's quality assurance services are complemented by standards-related research carried out in collaboration with BFRL researchers.

AMRL research associate Kathryn Tice preparing hot performance graded asphalt binder test samples for placement in a pressurized aging vessel.

ACI

(AMERICAN CONCRETE INSTITUTE)

Dr. Geoffrey Frohnsdorff, Building Materials Division, has been elected to ACI's Board of Direction.

ACI Committee 236 Materials Science of Concrete

Dr. Chiara Ferraris chairs ACI Committee 236 Materials Science of Concrete, and its Subcommittee 236a Fresh Concrete Workability. In her role as chair of Subcommittee 236a, Dr. Ferraris led an international comparison of concrete rheometers at the Laboratoire Centrale de Ponts et Chaussees, Nantes, France, in October 2000. A report on the findings has been published by NIST.

ACI Building Code Committee

Dr. H.S. Lew, Structures Division, serves on the American Concrete Institute Committee 318, which is responsible for developing the ACI *Building Code Requirements for Structural Concrete*. Dr. Lew introduced new curing provisions for concrete based partly on research on curing requirements for durability and strength led by the Structures Dr. Nicholas J. Carino as part of BFRL's HYPERCON Partnership for High Performance Concrete Technology.

ACI Committee 440 Fiber Reinforced Polymers

Dr. Dat Duthinh, Structures Division, plays an active role in the American Concrete Institute's Committee 440 that produced the *Guide for the Design and Construction of Concrete Reinforced with FRP Bars*. The guide was published as the first in a new category of ACI documents dealing with emerging technologies. The construction industry considers the guide an important milestone toward the more widespread use of composites in infrastructure.

ACI High Performance Concrete Committee

Dr. Geoffrey Frohnsdorff was appointed chair of the Subcommittee on High-Performance Concrete of the American Concrete Institute's Technical Activities Committee. The mission of the subcommittee is "to provide leadership and guidance on high-performance concrete for all ACI activities." He also chairs an ad hoc task group of three ACI committees—Hydraulic Cements, Knowledge-Based Systems and Mathematical Modeling of Materials, and Materials Science—to oversee a cooperative pilot activity in the development of an interoperable guide to selection and use of cements.

ACI Specifications Committee

Dr. Nicholas J. Carino, Structures Division, was recently appointed Chair of the Specifications Committee, which is responsible for coordinating the standard specifications issued by ACI and maintaining the Specification Manual covering the standard format of ACI specifications.

ACI Committee 216 Fire Resistance and Fire Protection of Structures

Dr. Long Phan, Structures Division, was named Chair of the joint ACI Committee 216 Fire Resistance and Fire Protection of Structures. The committee produced *Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies (ACI 216.1R-97).*

AISC
(AMERICAN INSTITUTE OF STEEL CONSTRUCTION)

Mr. Robert Lipman, Building Environment Division, and Dr. Kent Reed, in the same division, have been working for the past several years to support the AISC Electronic Data Interchange Initiative. The purpose of the initiative is to create a means for collaboration and data sharing among the various parties involved in steel construction. Dr. Reed participated on the AISC Task Force whose recommendation to endorse Version 2.0 of the CIMsteel Integration Standards (CIS/2) was adopted by the AISC Board of Directors. Mr. Lipman has been participating in the AISC-facilitated technical workshops and translator implementation activities.

AISC Committee on Specifications

Dr. John L. Gross, Structures Division, was appointed to serve on the American Institute of Steel Construction Committee on Specifications. The Committee on Specifications is responsible for developing requirements for the design, fabrication, and erection of steel buildings.

ASCE
(AMERICAN SOCIETY OF CIVIL ENGINEERS)

SEI/ASCE's Executive Committee on Codes and Standards

Dr. H. S. Lew, Structures Division, serves on the SEI/ASCE's Executive Committee on Codes and Standards. He worked closely with standards committees that develop standards for seismic evaluation and rehabilitation of buildings, and for the testing and evaluation of seismic isolation systems and components. The latter standard is based on work carried out by the Structures Division.

ASCE Committee ASCE-7

Dr. Emil Simiu, Structures Division, is a member of the American Society of Civil Engineers' Committee on Minimum Design Loads for Buildings and Other Structures (ASCE-7).

ASCE Committee on Structural Condition Assessment of Existing Buildings

Mr. James Pielert, AASHTO Materials Testing Laboratory, chairs the American Society of Civil Engineers' Standards Committee on Condition Assessment of Existing Buildings which recently updated *Guideline for Structural Condition Assessment of Existing Buildings* (SEI/ASCE 11-99), and prepared the new *Guideline for Condition Assessment of the Building Envelope* (SEI/ASCE 30-00).

ASHRAE

(AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS, INC.)

ASHRAE Standards Committee

Mr. Brian Dougherty, Building Environment Division, began a four-year term on the Standards Committee in July 2001, replacing Dr. Piotr A. Domanski, also of the Building Environment Division. The committee is responsible for overseeing the development and maintenance of all ASHRAE standards, guidelines, and code language documents. Mr. Dougherty is a member of the Inter-Society Liaison and the Technical Committee Liaison Subcommittees while having specific responsibility as the liaison to the ten technical committees within Section 8.

ASHRAE 37R Methods of Test for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment

Mr. Brian Dougherty is the lead editor on this revision of the standard, which was last updated in 1988. The standard is being updated to reflect current laboratory practices and instrumentation and to better address newer equipment features. The laboratory test methods described in the standard are used to obtain the performance data that is ultimately used in calculating federally-mandated seasonal rating descriptors. The document is presently in the public review process.

ASHRAE Standard 62 Ventilation for Acceptable Indoor Air Quality

Dr. Andrew Persily, Building Environment Division, chairs the committee responsible for revising *ASHRAE Standard 62 Ventilation for Acceptable Indoor Air Quality*. This committee is converting the current version of the standard into code language suitable for adoption by code bodies and is updating the technical content of the document. This standard contains HVAC system and building design and operation requirements for providing acceptable indoor environments. The committee's work has focused on system design requirements and calculation methods for determining design ventilation rates. The efforts of the committee have led to the publication of the first revision of the standard in 10 years, Standard 62-1999. This new version of the standard contains information relating ventilation to indoor carbon dioxide levels that is based upon BFRL research.

ASHRAE Standard 118.2 Method of Testing and Rating Residential Water Heaters

Dr. William Healy, Building Environment Division, is a voting member of ASHRAE SPC 118.2 Method of Testing and Rating Residential Water Heaters. This standard governs the evaluation of the energy factor which rates the thermal efficiency of residential water heaters and the first-hour rating which provides a metric for the amount of hot water provided by a tank. The committee is currently considering changes in this test procedure to correct errors in calculations and to make the procedure more consistent. Work has been undertaken to determine the differences between the ASHRAE procedure and the Department of Energy's procedure in an effort to align the two methods of test. A first draft of a revised document is currently being prepared for public comments.

ASHRAE 135.1P Method of Test for Conformance to BACnet

Mr. Steven T. Bushby, Building Environment Division, was the principal author of a draft standard, *ASHRAE 135.1P, Method of Test for Conformance to BACnet*. This proposed standard defines detailed testing procedures for verifying that control products correctly implement the BACnet communication protocol.

Although still in the public review process, 135.1P has already been adopted by the newly-created BACnet Manufacturers Association and the BACnet Interest Group – Europe (BIG-EU) as the basis for testing and listing programs in the United States and Europe.

Mr. Bushby is Chairman of ASHRAE Standing Standard Project Committee 135 (SSPC 135) that maintains the BACnet communication protocol standard for building automation and control systems. Three other new additions to the BACnet standard were developed in cooperation with industry. Addendum *c* contains new features to meet the special communication needs of life safety systems. Addendum *d* defines a concept called BACnet Interoperability Building Blocks (BIBBs) used to make it easier to specify BACnet systems. Addendum e provides an interoperable mechanism for manufacturers or other organizations to extend the capabilities of BACnet and publish the extensions for others to use.

BACnet was recently translated into Chinese, Japanese, and Korean. It has been adopted as a Korean national standard, a European Community prestandard, and has been proposed as an ISO standard.

ASME

(AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ASME Solar Energy Division

Dr. A. Hunter Fanney, Building Environment Division, is a member and past chairman of the ASME's Solar Energy Division. This Division is responsible for coordinating all solar energy activities within ASME including the Journal of Solar Energy Engineering, annual conferences, student activities related to solar energy, and awards.

ASTM

ASTM Committee C01 Cement

Mr. James Pielert, is committee secretary and a member of the Executive Subcommittee of ASTM Committee C01, Cement; he also chairs the Joint Subcommittee on International Activities of ASTM C01 and C09. Dr. Geoffrey Frohnsdorff, vice chair of the committee also serves on the Executive Subcommittee of C01.

ASTM C01.23 Subcommittee on Computational Analysis

Mr. Paul Stutzman, Building Materials Division, chairs the task groups on X-Ray Diffraction Analysis and Petrographic Analysis in ASTM Subcommittee C01.23, Compositional Analysis. Under his leadership, standards for improved characterization of portland cements in terms of the phases present using these two techniques have been established.

ASTM Committee C09 Concrete and Concrete Aggregates

Dr. Nicholas J. Carino, Structures Division, is writing draft revisions to ASTM C 42 (Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete). The revisions will take into account new research findings on the effects of moisture conditioning before testing cores for strength. He also developed a revision of ASTM C 900 Test Method for Pullout Strength of Hardened Concrete, that enhances the procedure for calibrating test instruments. Dr. Carino also chairs Subcommittee C09.64, Nondestructive and In-Place Testing and the task group on testing high strength concrete.

Mr. James Pielert is a member of the Executive Subcommittee of ASTM C09.

Mr. Raymond Kolos, Research Associate with CCRL, chairs ASTM Subcommittee C09.97, Manual of Testing (for concrete and concrete aggregates).

ASTM Committee D04 Road and Paving Materials

The following CMRL research associates participate in Committee D04 activities: Mr. Peter Spellerberg serves on the Executive Subcommittee of ASTM D04, and chairs Subcommittee D04.95, Quality Control, Inspection, and Testing Agencies; Mr. Robert Lutz chairs ASTM Subcommittee D04.46, Durability and Distillation Tests (asphalt); and Mr. David Savage chairs ASTM Subcommittee D04.30, Methods of Sampling.

ASTM Committee D18 Soil and Rock

Mr. Ronald Holsinger, Building Materials Division, serves on the Executive Subcommittee of ASTM Committee D18 Soil and Rock, and is secretary to Subcommittee D18.05 Strength and Compressibility of Soils and Subcommittee D18.03 Texture, Plasticity and Density Characteristics of Soils.

ASTM E5 Committee on Fire Standards

Mr. James R. Lawson, Fire Research Division, is a voting member of the ASTM E5 Committee on Fire Standards and the NFPA Fire Test Technical Committee. These committees develop fire standards for building construction, transportation and furnishings. These fire standards are used by the building codes and other regulating authorities throughout North America. In addition Mr. Lawson is a voting member (Mr. Robert Vettori alternate) of the ASTM F23 Committee on Protective Clothing, NFPA Committee for the Standard on Protective Ensemble for Structural Fire Fighting and the NFPA Committee on Special Operations Pro-tective Clothing and Equipment. These technical committees develop standards for protective clothing and equipment used by the fire service in North America. Fire standards and protective clothing and equipment standards are under constant development and revision as new knowledge and technology becomes available.

ASTM C16 Committee on Thermal Insulation

Mr. Robert R. Zarr, Building Environment Division, is the task group chair of a new standard activity covering the development of database formats for thermal transmission data obtained by ASTM C16 Standard Test Methods. Mr. Zarr has also prepared a precision and bias guideline for C16. The precision and bias checklist was approved by the membership in 2000 and is now required for submission of all C16 standards. Mr. Zarr also chairs C16 task groups on the design and operation of guarded hotplate apparatus.

ASTM Standing Committee on Publications

Dr. Mary McKnight, Building Materials Division, was appointed to the ASTM Standing Committee on Publications for a three-year term. The Committee advises the Society's Board of Directors on the formulation of publications policy and administers the Society's publications program, except for the *Annual Book of ASTM Standards.*

ASTM Subcommittee E06.23 Lead Hazards Associated with Buildings

Dr. Mary McKnight chairs ASTM Subcommittee E06.23, Lead Hazards Associated with Buildings. Under her leadership, more than 25 standards for use in abatement of hazards from leaded paint in buildings have been established.

ASTM Subcommittee E06.66 Performance Standards for Dwellings

Dr. Walter Rossiter, Building Materials Division, is chairman, *pro tem*, of ASTM Subcommittee E06.66 on Performance Standards for Dwellings. He is also chairman of the E06.66 Task Group on Durability, which recently completed a draft standard entitled, *Guide for Specifying and Evaluating Performance of Single Family Attached and Detached Dwellings Durability*. The standard is likely to be issued by ASTM in the spring of 2001.

Dr. Robert Chapman, Office of Applied Economics, is writing the economics attribute standard that ties together the E06.66 family of standards that define total building performance.

ASTM Subcommittee E06.81 Building Economics

Dr. Harold E. Marshall, Office of Applied Economics (OAE), has been the sole chairman of ASTM's Building Economics Subcommittee, E06.81, since its inception in 1979. He has played major authorship, educational, and leadership roles in writing and shepherding successfully 16 standards and two software products through the ASTM standardization process. His recent efforts are focused on a standard elemental building classification called UNIFORMAT II. Based on two NIST reports co-authored by Dr. Marshall, the ASTM standard classification provides the building community a common elemental classification for the description, economic analysis, and management of buildings over their life cycle. UNIFORMAT II is helping owners, project managers, designers, builders, and facility managers construct and manage their buildings more cost effectively. Other building economics standards based on research of Dr. Marshall and his OAE staff include methods for measuring and evaluating life-cycle costs, net benefits or savings, and adjusted internal rates of return.

Dr. Robert Chapman, serves as secretary to E06.81 and chairs the task group on economic techniques. He was the lead author on *User's Guide to AHP/Expert Choice for ASTM Building Evaluation*, a companion document to ASTM software that helps users evaluate construction alternatives where they seek to maximize multiple objectives.

CCRL

(CEMENT AND CONCRETE REFERENCE LABORATORY)

Established at NIST (then NBS) as the Cement Reference Laboratory in 1929 in response to a request from Congress, the ASTM-sponsored Cement and Concrete Reference Laboratory (CCRL) is a research associateship that provides a highly-valued quality assurance mechanism for laboratories that use ASTM cement and concrete standards. With Mr. James Pielert of AASHTO as Manager and Mr. Raymond Kolos of ASTM as Assistant Manager, and a staff of 18 ASTM research associates, the CCRL provides, upon request, as reimbursible services, laboratory inspection and proficiency sample programs. In 2001, over 900 laboratories participated in the CCRL programs. For cement and concrete laboratories that wish to participate in the AASHTO Accreditation Program (AAP), results of laboratory inspections carried out by the CCRL are the basis for accreditation. CCRL's quality assurance services are complemented by standards-related research carried out in collaboration with BFRL researchers.

CIB

(INTERNATIONAL COUNCIL FOR RESEARCH AND INNOVATION IN BUILDING AND CONSTRUCTION)

CIB W14 Fire

Mr. Richard Bukowski, Fire Research Division, has recently been appointed chair of CIB Working Commission 14 on Fire. The oldest working commission in existence, W14 has a long history of making major contributions to the fire science and engineering fields.

CIB TG37 Performance-Based Buildings

Mr. Richard Bukowski, participates in CIB TG37, a task group that is developing infrastructure and policy in support of performance regulatory systems, internationally. TG37 is closely linked to the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) that is made up of the chief building code official for each member country and who share common experiences and problems in the operation of performance regulatory systems.

IAI

(INTERNATIONAL ALLIANCE FOR INTEROPERABILITY)

NIST has joined the International Alliance for Interoperability/North America as a government member. Dr. Kent Reed, Building Environment Division, represents NIST in the IAI/NA, is a member of the IAI Technical Advisory Group that functions at the international level, and participates in technical projects in the Building Services Domain. The IAI is a global standards-setting organization dedicated to promoting effective means of exchanging information among all software platforms and applications serving the Architecture, Engineering, Construction, and Facility Management (AEC+FM) community.

ICC

(INTERNATIONAL CODE COUNCIL)

ICC Performance Committee

Mr. Richard Bukowski completed a three-year assignment to the ICC Performance Building Code and ICC Performance Fire Code drafting committees. These two committees eventually merged and produced the ICC Performance Code for Buildings and Facilities, the first combined U.S. building and fire code and the first U.S. performance-based code. This document has entered into the ICC code development process where it is open to code change proposals prior to formal adoption.

Mr. Bukowski has been named to the ICC Performance Code development committee, which is responsible for accepting or rejecting these proposed changes.

ISO

(INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO TAG8

Mr. Richard Bukowski was appointed U.S. representative to ISO TAG8 by ANSI which provides the U.S. Secretariat. TAG8 is a technical advisory group to the Technical Management Board (TMB) of the International Organization for Standardization (ISO) which develops ISO standards. A current activity is the development of an ISO policy on performance standards.

ISO TC 59 Building Construction

Dr. Geoffrey Frohnsdorff chairs Subcommittee 14, Design Life, of ISO Technical Committee 59, Building Construction. The subcommittee is preparing a standard, ISO 15686, Buildings and Constructed Assets: Service Life Planning, which will have at least seven parts. Part 1, General Principles, and Part 2, Service Life Pre-diction Procedures, have already been published and Part 3, Performance Audits and Reviews, should be completed in 2001.

ISO TC 86 Refrigeration and Air-Conditioning

ISO's Technical Committee 86 Refrigeration and Air-Conditioning is composed of eight subcommittees that address topics such as terms and definitions, safety, and testing and rating methods for refrigeration and space-conditioning equipment. Mr. Brian Dougherty participates as a member of the U.S. Technical Advisory Group (TAG) for ISO TC 86. The TAG monitors and formulates the U.S. position on all TC 86-sponsored standards activities. BFRL is also represented on ISO Working Groups 1 and 5 within Subcommittee 6, Factory-Made Air-Conditioning and Heat Pump Units. WG1 is working to revise two testing and rating standards that apply to unitary air-conditioners and heat pumps. WG5 is developing a testing and rating standard for multi-split air conditioners and heat pumps.

ISO TC92 Fire Safety

The Fire Research Division has several participants in TC92. Dr. Richard Gann chairs SC3 Fire Threat to People and the Environment, and participates in the Technical Program Management Group. Dr. Walter Jones participates in SC4 Fire Safety Engineering.

ISO TC184 Industrial Automation Systems and Integration

Mr. Mark Palmer, Building Environment Division, participates in Subcommittee 4 Independent Data, of ISO TC184 Industry Automation Systems and Integration, and leads the development of ISO 10303 Application Protocols for the Process Plant Industries, as well as the development of the Test Case Guidelines for SC4 standards. In collaboration with the industrial consortium PlantSTEP, NIST developed and demonstrated the first ISO 10303 application protocol (AP227) for exchanging CAD/CAE information for process plants.

In collaboration with PlantSTEP, engineering, construction and shipbuilding companies and the U.S. Naval Sea Systems Command, Mr. Palmer is developing extensions to AP227 to support HVAC design and installation, piping fabrication and inspection, and cableway design and installation.

ISO TC 205 WG 3 Building Control System Design

Mr. Steven Bushby, is convener of ISO TC 205 WG 3 Building Control System Design. The Working group is developing a multi-part international standard that addresses several issues related to building control systems including control system functionality, communication protocols, system specifications and project management. ANSI/ASHRAE Standard 135-1995 was adopted as the committee draft (CD) for the communication protocol portion of this standard.

NES

(NATIONAL EVALUATION SERVICE)

Building Innovation Center of the NES

Dr. Walter Rossiter drafted a protocol for evaluating the durability of innovative building materials and components for the Building Innovation Center of the National Evaluation Service, which serves two of the U.S. model code organizations.

NFPA

(NATIONAL FIRE PROTECTION ASSOCIATION)

NFPA Standards Council

Mr. Richard Bukowski, was appointed to the NFPA Standards Council by the NFPA Board of Directors in January 2000. The Standards Council is the body that administers the NFPA Codes and Standards system including making all committee appointments, initiating and terminating standards projects and issuing all documents. This is an especially important time for the Standards Council in administering the development of the NFPA Building Code and related Codes through strategic partnerships. Appointments to the thirteen-member Council run for two, three-year terms.

NFPA Alternative Approaches to Life Safety Committee

Mr. David Stroup, Fire Research Division, chairs NFPA 101A Committee on Alternative Approaches to Life Safety. The Alternative Approaches to Life Safety standard provides methodologies for measuring equivalency to the prescriptive requirements of *NFPA 101, Life Safety Code*. The document includes several Fire Safety Evaluation Systems (FSES) developed at NIST for various building occupancy types. As chair of the committee responsible for this fire safety standard, Mr. Stroup presented the committee's report for adoption at the NFPA Fall Meeting held in Orlando, FL on November 15, 2000. At this meeting, the NFPA membership approved the latest revision of the standard and, more significantly, accepted the first software package, useful for evaluating equivalency, for inclusion in the standard. The software, which was developed by Hughes Associates through a contract with BFRL, implements an enhanced Fire Safety Evaluation System for business type occupancies.

NFPA Toxicity Advisory Committee

Dr. Richard Gann, chairs the NFPA Toxicity Advisory Committee. This committee brings special expertise on combustion toxicity to advise any other NFPA technical committee on toxicity issues that might be part of any proposal under consideration.

NFPA Automatic Sprinkler Committees

Mr. Daniel Madrzykowski, Fire Research Division, is chair of the Technical Committee on Residential Sprinkler Systems. This committee is responsible for developing the standard on the design and installation of sprinklers in one-and two-family dwellings, and in residential occupancies up to 4 stories in height. In addition, Mr. Madrzykowski serves on the Technical Correlating Committee on Automatic Sprinklers, leading the New Technology Task Group and is the NIST alternate on the NFPA Technical Committee on Sprinkler System Discharge. Mr. Madrzykowski revised the residential sprinkler section in the *NFPA Automatic Sprinkler Systems Handbook, 8th ed.*

NFPA 921 Guide for Fire and Explosion Investigations

Mr. Anthony Putorti Jr., Fire Research Division, is a member of the NFPA 921 Committee, Guide for Fire and Explosion Investigations. This committee provides guidance to investigation professionals based on scientifically defensible materials and referenced technical data. NIST utilizes its research expertise to provide the latest technical and scientific research information to the committee. At the current time, NIST is studying the formation of fire burn patterns, which is one of the tools used by investigators to determine the origins and causes of fires and explosions. The burn pattern research is supported by the National Institute of Justice via the NIST Office of Law Enforcement Standards and the United States Fire Administration.

NFPA Halon Alternatives Committee

Dr. William Grosshandler, Fire Research Division, is a member of the NFPA 2001 committee developing standards for replacements for halon extinguishing agents. This activity is coordinated with the BFRL research on halon replacements.

NFPA Life Safety Code for Detention and Correctional Facilities

Researchers in the Office of Applied Economics have developed new software to help prison facility managers and fire safety engineers minimize the cost of complying with the NFPA *Life Safety Code for Detention and Correctional Facilities*. The project was funded by the National Institute of Justice through the NIST Office of Law Enforcement Standards. Called ALARM 2.0 (Alternative Life-Safety Analysis for Retrofit Cost Minimization), the software quickly finds the least-cost compliance plan by using construction cost estimating algorithms and a linear programming optimization model. The user first provides minimal information about the facility and then enters data about the initial (or current) safety levels for 13 fire safety parameters. The user also enters data on the dimensions and quantities of the building features that must be modified to improve safety. The cost estimating algorithms quickly estimate the construction costs of every possible safety improvement (which can be overridden by the user). The software then automatically finds the least-cost compliance plan for the facility. ALARM includes a User Manual, an extensive help system and tutorial, a sample project file, and a detailed printed report describing the least-cost construction plan to achieve compliance with the *Life Safety Code*. ALARM 2.0 is being distributed by the NFPA and the American Correctional Association.

NFPA National Fire Alarm Code Technical Correlating Committee

Mr. Richard Bukowski serves on the TCC for the National Fire Alarm Code. Like other TCC's this committee addresses technical consistency and correlation among the technical committees responsible for specific parts of the Code.

NFPA and ASTM Rail Transportation Committees

Mr. Richard Peacock, Fire Research Division, represents NIST and DOT on the NFPA 130 committee and the ASTM E5.17 committee developing standards for fire safety in passenger rail vehicles. These activities are tied directly to the DOT funded work to develop advanced fire hazard analysis methods to be used in federal regulation.

NFPA Safety to Life Correlating Committee

Mr. Richard Bukowski is a member of the Technical Correlating Committee (TCC) for the Safety to Life Project. The TCC provides oversight to the technical committees developing requirements for individual topics and assures that the requirements are consistent and correlated throughout the document.

NFPA Urban/Wildland Interface Committee

Mr. Daniel Madrzykowski is a member of the NFPA Technical Committees on Forest and Rural Fire Protection and has contributed to the standards and guides on Application of Class A foam in Structural Fire Fighting and Fire-Fighting Chemicals for Class A Fuels. Mr. Madrzykowski also serves as NIST's principal member on the Water Mist Fire Protection Systems Technical Committee.

PIEBASE

PIEBASE is an international umbrella organization for process and construction industry consortia active in the development of ISO STEP (Standard for The Exchange of Product model data) application protocols and other international standards for exchanging and sharing industrial data. Mr. Mark Palmer, Building Environment Division, participates in the PIEBASE Working Group. PIEBASE coordinates the standards development programs of the participating consortia and provides a forum for international collaboration on developing and using in-formation technology standards for the benefit of the global process industries.

RILEM

(INTERNATIONAL UNION OF RESEARCH AND TESTING LABORATORIES FOR MATERIALS AND STRUCTURES)

RILEM Coordinating Committee

Mr. Dale Bentz, was appointed to the Coordinating Committee of RILEM for a three-year term. RILEM is a pre-standards organization that produces technical documents that frequently become the basis for national or international standards. The Coordinating Committee has oversight of the technical quality and progress of the work in all RILEM technical committees.

RILEM Technical Committee HTC Mechanical Concrete Properties at High Temperatures: Modeling and Applications

Dr. Long Phan is a Senior Member of the newly-formed RILEM Technical Committee HTC, Mechanical Concrete Properties at High Temperatures: Modeling and Applications. TC HTC is the successor to the former committee RILEM 129-MHT Test Methods for Mechanical Properties of Concrete at High Temperatures.

SFPE

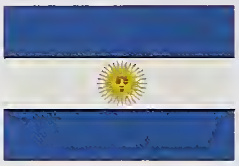
(SOCIETY FOR FIRE PROTECTION ENGINEERING)

SFPE Task Group on Fire Model Evaluation

Mr. Daniel Madrzykowski is the Chairman of the Society of Fire Protection Engineers' Task Group on Fire Model Evaluation. This group develops evaluation reports that provide information on the technical features, theoretical basis, assumptions, limitations and sensitivities of selected computer models. The principle means of evaluation is comparing model predictions to full-scale experimental data. The group recently completed the evaluation of one of the most heavily used models in the fire protection industry, DETACT-QS and the group is currently working on the evaluation of another fire model developed at NIST, ASET-B. Mr. Madrzyskowi also serves as a member of SFPE's Technical Steering Committee and their Publications Committee.

International ACTIVITIES

Argentina



At the invitation of the Federation of Societies for Coatings Technology (FSCT), Dr. Jonathan Martin gave a 4-hour short course on service life prediction methodologies in Buenos Aires, Argentina, in July, 2001. The purpose was to increase collaboration between the FSCT and South American countries.

Canada

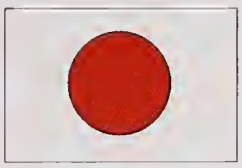
Mr. Kenneth Snyder spent the summer of 2001 on a sabbatical at Laval University in Quebec City, Canada. While there, he collaborated with Dr. Jacques Marchand of Laval on the theory of transport of water and aqueous solutions in concrete, and on the development of a molecular dynamics approach to modeling the reactions of cements with water.

Dr. Tinh Nguyen serves on the Steering Committee for the 9th International Conference on the Durability of Building Materials and Components to be held in Brisbane, Australia, in March, 2002. NIST and the National Research Council of Canada initiated this series of conferences in 1978, and both continue to be represented on the Steering Committee.

Denmark

In each of the summers of 1999 and 2000, Mr. Dale Bentz spent three months on sabbatical as the Knud Hojgaard Visiting Professor at the Danish Technical University. While at DTU, he lectured on the computational material science of cement and concrete and carried out research on the transport of water in cement-based materials. He also spent a week at the European Synchrotron Radiation Facility (ESRF) using the high-intensity x-ray beam line in carrying out high-resolution x-ray tomographic studies of early-age microstructural changes taking place during the hardening of a cement paste

Japan



The United States-Japan Cooperative Program in Natural Resources (UJNR) was founded in 1964 in response to the need for improved engineering and scientific practices through exchange of technical data, information, and research personnel between the United States and Japan. The UJNR Panel on Wind and Seismic Effects was established in 1969. The U.S.-side Panel is chaired by Dr. S. Shyam Sunder. Mr. Stephen A. Cauffman serves as the Secretary-General for the U.S.-side Panel.

The UJNR Panel on Wind and Seismic Effects focuses on the effects of natural events such as earthquakes, high winds, tsunami and storm surge on buildings and other structures, and on the development of technologies to mitigate these effects. The Joint Panel meets annually, alternating between the U.S. and Japan. Meetings consist of technical sessions and site visits to research laboratories and civil works projects. Task Committees are chartered by the Joint Panel to address particular research topics of mutual interest to the U.S. and Japan and facilitate information exchange through focused workshops, joint research projects and exchange of researchers.

The UJNR Panel on Wind and Seismic Effects developed a strategic plan following its May 2000 meeting in the U.S. and adopted the strategic plan at its May 2001 meeting in Japan. The purpose of the plan is to streamline the operation of the Panel, ensure that Task Committees are active and have strong bilateral leadership, encourage broader participation by the private sector and academia, and to position the Panel for future growth. Four Task Committees, operating under the new structure, were chartered at the May 2001 meeting. Additional Task Committees may be chartered by the Joint Panel to address topics where there is strong bilateral interest and leadership.

Vietnam

Dr. Walter Rossiter was a member of the U.S. team participating in the Workshop on Standards in Trade: Building and Construction, that was held in Vietnam in July 2000. The Workshop was co-sponsored by NIST and the Vietnamese Directorate for Standards and Quality and was held to inform representatives of the Association of Southeast Asian Nations of the important role that codes and standards play in building construction. Dr. Rossiter was a key speaker providing an overview of the U.S. building regulatory system and describing the interface between the U.S. building design and regulatory communities.

Six guest researchers who joined the Inorganic Building Materials Group in 2001 are, from left to right, Dr. Kenneth Chong, a program manager from the U.S. National Science Foundation, Mr. Frank Chaventre, a researcher from CSTB, France, Mr. Erik Neilsen, a doctoral student from the Technical University of Denmark, Ms. Xiuping Feng, a researcher from Northwestern University, Ms. Aicha Ghezal, a graduate student from the University of Sherbrooke, Canada, and Mr. Bryan Keen, a technician from the Building Research Association of New Zealand.

Staff HIGHLIGHTS

One of BFRL's great strengths is the excellence of its staff. Their competence and contributions are consistently recognized by peers in professional societies. Examples of recent staff awards, other recognitions and key appointments are listed below.

Gold Medal

The Gold Medal Award is the highest honor award conferred upon an employee by the Department of Commerce. It is bestowed for "distinguished performance characterized by extraordinary, notable, or prestigious contributions that impact the mission of the Department of Commerce and/or one operating unit and which reflect favorably on the Department." Awards are given in the following categories: leadership, personal and professional excellence, scientific/engineering achievement, employee development, customer service, administrative/technical support, and public service or heroism.

Dr. Takashi Kashiwagi, Fire Research Division, received the Department's Gold Medal for leading the transformation of materials flammability from a field dominated by prediction uncertainties so large that they were of little value to manufacturers and regulators, to a field based upon scientific understanding and sound engineering. New flame retardant principles and models that he has advanced are the tools to

assure the U.S. plastics industry that modifications to their products will manifest the intended fire performance without significant reductions in their physical properties, resulting in new and improved products for domestic and international markets.

Silver Medal

The Silver Medal is the second highest honor awarded by the Department for "exceptional performance characterized by noteworthy or superlative contributions that have a direct and lasting impact".

Ms. Geraldine Cheok, Dr. H.S. Lew and **Dr. William Stone**, all of the Structures Division, received the Department's Silver Medal for 13 years of research that led to the development and acceptance of an innovative precast concrete beam-to-column connection that can be used for high-rise construction in high-risk earthquake regions. It is more cost-effective than conventional steel or cast-in-place connections. The connection was used to construct a 39-story precast concrete building in San Francisco, the tallest concrete frame building ever built in a high-risk seismic zone. Other construction projects are underway that use the concept and it is being adopted in codes and standards.

Dr. Kevin McGrattan and **Dr. Glenn Forney**, both of the Fire Research Division, received the Department's Silver Medal for development of the Fire Dynamic Simulator and Smokeview. These computer programs were released to the public 18 months ago and are revolutionizing fire modeling. Practicing engineers and code officials can now perform computational fluid dynamics calculations and visualize fire effects with high spatial and temporal resolution using common personal computers. The programs have been used in projects to successfully get draft curtain requirements removed from sprinkled warehouse facilities and to demonstrate reasons for fire fighter deaths in the reconstruction of fires. This latter project has major implications for the future training of firefighters.

Bronze Medal

The Bronze Medal Award is the highest honorary recognition available for Institute presentation. The award, approved by the Director, recognizes work that has resulted in more effective and efficient management systems as well as the demonstration of unusual initiative or creative ability in the development and improvement of methods and procedures. It also is given

for significant contributions affecting major programs, scientific accomplishment within the Institute, and superior performance of assigned tasks for at least five consecutive years.

Dr. Mark A. Ehlen, Office of Applied Economics was recognized for outstanding technical work in producing BridgeLCC—a unique, user-friendly software product that helps designers, owners, and materials suppliers estimate life-cycle costs of bridges made from both new-technology and conventional materials. Signi-ficant contributions are the development of a life-cycle costing framework for selecting economically efficient building materials, a bridge elemental classification adopted by ASTM as a standard, and a tool based on the BFRL concrete service life prediction model that estimates the service lives of bridge components made of concrete. BridgeLCC is cutting-edge, interdisciplinary software for selecting cost-effective, new technology materials.

Dr. Jiann C. Yang, Fire Research Division, was recognized for advancing fire suppression measurement science by developing the Dispersed Liquid Agent Fire Suppression Screen apparatus. For the first time, new chemicals, that have other positive attributes, but that are in a liquid phase, can now be evaluated side-by-side with halon 1301 and other gaseous materials in a system that requires only a few grams of material. The new apparatus provides assurance that the suppression effectiveness ranking is a scientifically sound predictor of the relative effectiveness of the new material in full-scale.

Mr. Daniel Madrzykowski, Fire Research Division, received the Bronze Medal for his tireless efforts and exceptional leadership in collecting, analyzing and using data from structure fires to educate professionals as well as the general public on building fires, fire hazards, and the NIST Fire Program. Over a period of 5 years, he worked closely with local fire departments, the U.S. Fire Administration, the Bureau of Alcohol, Tobacco, and Firearms, the International Association of Arson Investigators, and the National Institutes of Occupational Safety and Health to conduct fire experiments on a wide variety of structures from single houses to multi-story apartment buildings. He created a database of structural fire scenarios that goes beyond anything possible using the NIST fire facilities. In addition, he provided numerous interviews to radio, television and other news media to educate the public about these large-scale fire experiments.

Dr. John Gross, Structures Division, received the Bronze Medal for the development of a science-based design guide for seismic retrofit of welded moment frame buildings. The 1994 Northridge earthquake caused a significant number of unexpected failures in beam-to-column connections in welded steel buildings. He developed a national plan for addressing the technical issues posed by the failures, determined and documented the specific causes of the failures, and then determined the three most promising connection modification concepts to eliminate the inherent vulnerability of hundreds of thousands of similar connections in buildings located in seismically active regions throughout the world. The concepts were experimentally validated in full-scale tests at three leading universities and then incorporated into a new Design Guide published by the American Institute of Steel Construction.

Equal Employment Opportunity/Diversity Award

The Equal Employment Opportunity/Diversity Award recognizes significant EEO/diversity contributions that have been performed in an outstanding manner by an Institute employee. The award was initiated in 1977.

Mr. Nelson P. Bryner and **Dr. Kathryn M. Butler**, both of the Fire Research Division, are recognized for their joint voluntary effort, initiative, and perseverance toward the active advancement of diversity at NIST. As chairs of the first-ever diversity committee at NIST, the BFRL Diversity Committee, they built and led a team that made significant accomplishments in improving communication, developing careers, fostering recruitment of an excellent and diverse staff, improving retention of existing staff and community outreach. Moreover, their flagship BFRL committee served as a model in the subsequent formation of diversity committees throughout NIST. Butler and Bryner's profound dedication to the advancement of diversity at NIST led to the initiation of a wide array of ongoing activities that will continue yielding positive results for many years to come.

Commerce Engineer of the Year Award

Dr. John Gross, Structures Division, has been named by the National Society of Professional Engineers as the "Engineer of the Year" for the U.S. Department of Commerce, National Institute of Standards and Technology. In addition, he has been named among the 33 agency winners to be in the "Top Ten" for Federal Engineer of the Year. Dr. Gross was cited for his work in seismic rehabilitation of welded steel frame buildings.

BFRL Communication Award (2000)

Dr. Mark A. Ehlen, Office of Applied Economics, received BFRL's 1999 Communication Award for his BridgeLCC 1.0 software, users guide, and web site. The user-friendly software helps bridge designers, owners, and materials suppliers estimate the life-cycle costs of new-technology materials such as FRP composites, high-performance concrete, and high-performance steel. BridgeLCC provides cutting-edge measurement technology that advances the life-cycle quality and economy of bridges and other constructed facilities. The Windows-based program is available in the form of a CD and users manual and in downloadable form from the BridgeLCC web site (*http://www.bfrl.nist.gov/bridgelcc*). Over 450 BridgeLCC CDs and user manuals have been distributed to state departments of transportation , private engineering firms, materials suppliers, and trade associations. Universities, building research institutes, and materials organizations in 7 countries have requested the software.

BFRL Communication Award (2001)

Mr. William D. Walton, Dr. Glenn Forney, Mr. Daniel Madrzykowski and **Mr. Robert Vettori**, all of the Fire Research Division, received the 2000 BFRL Communication Award for the compact disk presentation (NISTIR 6510) of their simulation/re-creation of the May 30, 1999, Cherry Road fire in which two fire fighters were killed. The compact disk (CD) is simple to use and the re-creation using BFRL's *Fire Dynamic Simulator* (FDS) computer model presents all pertinent time lines, floor plans, material properties, and a thorough discussion of the insights gained. Understanding of what happened and how the fatalities occurred is aided by model animations portraying the courses of variations in temperature, gas concentrations, and gas velocity gradients calculated to have occurred during the critical time. While this fire scene is not the first to have been simulated by computer models, it is the first that presents the physics and chemistry of fire phenomena at a level that fire fighters can readily understand. The use of the *FDS* to simulate and re-create the fire scenario and the packaging of the results on a CD has "radically advanced the state-of-the-art in fire scene/arson investigation, significantly impacted the investigating committee's inquiry, and significantly advanced the understanding of a fire scenario that involved the death of two fire fighters."

BFRL Communicator Award (2000)

Dr. Jonathan Martin, Building Materials Division, received the BFRL Communicator Award in recognition of the success of his sustained campaign extending over 20 years to introduce reliability concepts and life cycle testing to the coatings community, and the building materials community as a whole. In addition to communicating his ideas in print and in public forums, Dr. Martin has communicated successfully with senior scientists in several of the world's largest coatings companies. He has taught them how development and implementation of his ideas on service life prediction would enable them to reduce the time taken to bring new products to market.

BFRL Communicator Award (2001)

Dr. John Gross received the 2000 BFRL Communicator Award for addressing a critical public safety issue by communicating the results of his research on the seismic performance of welded steel buildings and influencing the American Institute for Steel Construction and the Federal Emergency Management Administration to publish design guides. The number of failures of beam-to-column connections in steel frames of buildings that occurred as a result of the 1994 Northridge earthquake near Los Angeles raised a critical public safety issue. Following the earthquake, at the request of leaders from the steel producing and fabricating industries, Dr Gross helped organize and conduct a workshop to develop a national plan to address the technical issues posed by the failures. Then, working in conjunction with the Structural Engineers Association of California (SEAOC), the Applied Technology Council (ATC), the California Universities for Research in Earthquake Engineering (CUREe) and the American Institute for Steel Construction (AISC), Dr. Gross initiated a multi-year program of coordinated research on seismic rehabilitation.

ACI Structural Research Award

Dr. William Stone, Structures Division, was selected by the American Concrete Institute to receive the ACI Structural Research Award for his co-authored paper on an experimental research on cumulative seismic damage in concrete columns. The experimental study was carried out in the Structures Division jointly with Drs. Ashraf El-Bahy, Sashi Kunnath, and Andrew Taylor. Their study, for the first time, showed that fatigue-based damage models offer a reliable means of determining seismic structural performance of bridge columns. In selecting their paper as the Most Meritorious Paper in 2000, the selection committee recognized that the results of their study would have significant impact on the seismic safety of highway bridges. In 1997 Dr. Stone jointly with Ms. Geraldine Cheok received the same award for their study on seismic performance of hybrid moment-resisting precast beam-column connections.

ACI International Conference Award

Dr. H. S. Lew, Structures Division, received the ACI International Conference Award for his sustained contributions to the repair and rehabilitation of concrete structures. The award is given triennially for individuals who made significant contributions in the area of concrete design and technology.

ACI Distinguished Chapter Member Award

Mr. James Pielert, Construction Materials Reference Laboratories, was the recipient of the Distinguished Chapter Member Award for the Year 2000 from the National Capital Chapter of the ACI. The award honors eminent Chapter members who have made exceptional contributions to the objectives of the Chapter and ACI. Mr. Pielert is a Fellow of the ACI and a former President of the National Capital Chapter.

ASCE Raymond C. Reese Research Prize

Dr. John Gross was selected by ASCE's Structural Engineering Institute as the recipient of the 2001 Raymond C. Reese Research Prize. This award is for his paper "Cyclic Testing of Steel Moment Connections Rehabilitated with RBS or Welded Haunch" published in the Journal of Structural Engineering in January 2000 and jointly authored with Professor Chia-Ming Uang and Mr. Kent Yu at the University of California at San Diego. The Raymond C. Reese prize is awarded to the author or authors of paper published by the society during the past year that describes a notable achievement in research structural engineering and which indicates how it can be used. Dr. Gross' paper describes the NIST-led work on retrofit of welded steel moment frame structures following the 1994 Northridge Earthquake. Dr. Gross joins a distinguished group of colleagues – including a several members of the National Academy of Engineering – who have received this award since its inception in 1970.

ASTM John C. Weaver Excellence in Leadership Award

Dr. Mary McKnight, Building Materials Division, received the 2001 John C. Weaver Excellence in Leadership Award from ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications. The award recognized her many important contributions to the Paint Committee through leadership of subcommittees and her service on the Executive Subcommittee as committee secretary and, later, as committee chair.

ASTM Walter C. Voss Award

Dr. Walter Rossiter, Building Materials Division, received the 2001 Walter C. Voss Award from ASTM for notable contributions to "knowledge in the field of building technology, with emphasis upon materials." Dr. Rossiter's contributions have been particularly important in the areas of roofing materials and abatement of hazards from leaded paint.

NFPRF Harry C. Bigglestone Award for Excellence in Communications

Mr. J. Randall (Randy) Lawson, Fire Research Division, and **Dr. William (Ruddy) E. Mell**, University of Utah, have been announced as the winners of the 2001 Harry C. Bigglestone Award for Excellence in Communications for their publication of the pioneering work on developing an accurate and flexible model of heat transfer through protective clothing for fire fighters. The study was funded jointly by NIST and United States Fire Administration. The award winning paper, A Heat Transfer Model for Fire Fighter's Protective Clothing, appeared in *Fire Technology*, Vol. 36, No. 1, 2000. The Bigglestone Award, sponsored by the National Fire Protection Research Foundation (NFPRF), Quincy, MA, is presented to the authors of the best paper submitted to *Fire Technology* during the previous year.

Notable Commerce Employee

Dr. Gregory Linteris, Fire Research Division, received recognition as a Notable Commerce Employee, one of only six NIST Scientists, and twelve Commerce employees overall, to be so recognized by the Secretary of Commerce. Dr. Linteris earned this honor by serving as a payload specialist astronaut on STS-83 and STS-94. He was chosen by NASA because of a unique combination of talents that he brought to the mission that had been honed during his tenure as a NIST researcher. His first flight, in April 1997, was cut short because of a fuel cell problem. He was back in space three months later as NASA re-flew the mission as STS-94, a feat representing the fastest turn-around of an orbiter and payload in shuttle history, and the first time an entire crew had flown together again in space. The success of the portion of the scientific study for which Dr. Linteris was responsible has been acknowledged through letters of support and conversations with leaders in the field of combustion science.

SFPE President's Award

Dr. David D. Evans, Fire Research Division, received the John J. Ahern President's Award in May of 2000 for strategic leadership of the Society of Fire Protection Engineers and the profession through his service as President of SFPE. The John J. Ahern President's Award of the SFPE honors individuals whose conspicuous contributions deserve very special recognition by the Society and its leadership.

Sigma Xi Young Scientist Award

Dr. Kevin McGrattan, Fire Research Division, was awarded the *2000-2001 NIST Chapter of Sigma Xi Young Scientist Award for Excellence in Scientific Research*. The award recognizes Kevin's outstanding research in the development and extension of computer models to predict fire dynamics.

Making a Measurable Difference at NIST Award

Mr. Darren L. Lowe, BFRL Headquarters, provided crucial help to the NIST Small Business Innovative Research (SBIR) Program to develop a unique information system that met SBIR's special needs when no appropriate commercial products could be found. SBIR managers contacted Mr. Lowe after learning he had developed a special question and answer capability for a BFRL database that might meet SBIR's needs. He immediately jumped into the task and developed the needed question and answer capability for SBIR in time for the FY2001 solicitation. Mr. Lowe did all this without he or his management worrying about time commitment, transfer of funds, or complaints about limited resources. He listened to the needs of the customer and provided outstanding technical support. Mr. Lowe's work benefits not just NIST but the many outside customers of the SBIR program.

Making a Measurable Difference Award

Ms. Marine Giraud, a student from the University of Lyon, who spent two years as a Guest Researcher in the Building Materials Division, received the Making a Measurable Difference Award for her initiative in establishing NIST's Guest Researcher Association (the GRA). In collaboration with other guest researchers, Marine took the lead in setting up the GRA and its very informative web site, to help provide new guest researchers, and others, with a support network and a source of advice on important practical matters, such as how to find affordable housing and where to buy a car. In forming the Association, Marine established a mechanism for helping guest researchers settle into their new environment, thereby making NIST a more welcoming place at which to work.

Honorary Membership of ASTM Committee C09

Dr. Nicholas J. Carino, Structures Division, was awarded Honorary Membership in ASTM Committee C09 on Concrete and Concrete Aggregates at the June 2000 committee week meeting in Orlando. Dr. Carino was recognized for outstanding service to the committee and for devotion to its objectives. He has held a variety of leadership positions on C09 including serving on the Executive Subcommittee, membership secretary, chair of the Subcommittees on Setting Time and Accelerated Strength Testing. He currently serves as chair of the Subcommittee on Nondestructive and In-Place Testing and the Task Group on Testing High Strength Concrete. He was the lead author on two new ASTM standards that evolved

from NIST research. One of these is ASTM C 1074 Practice for Estimating Concrete Strength by the Maturity Method, and the other is ASTM C 1383 Test Method for Meas-uring P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method. In addition, he provided leadership in major revisions
to several other standards under the Committee's jurisdiction. He also was the author of Chapter 15 on "Prediction of Potential Concrete Strength at Later Ages" in ASTM STP 169 C *Significance of Tests and Properties of Concrete and Concrete-Making Materials*. In June 2001, he was elected to chair Committee C09.

Dr. Mary McKnight, Building Materials Division, was elected to the Board of Governors of the Intersociety Color Council (ISCC) for a three-year term. The ISCC coordinates activities and stimulates progress in member bodies concerned with color.

Dr. Ed Garboczi, Building Materials Division was elected a Fellow of the American Ceramic Society in recognition of his pioneering contributions to the computational materials science of cement and concrete.

Dr. A. Hunter Fanney, Mr. Brian P. Dougherty and **Mr. Mark Davis**, all members of the Building Environment Division, received one of the four ASME Best Paper awards at the Forum 2001, Solar Energy: The Power to Choose, for the paper entitled "Measured Performance of Building Integrated Photovoltaics".

Dr. Howard Baum, Fire Research Division, was elected a Fellow and Chartered Physicist of the U.K. Insitute of Physics in October 1999, "In recognition of your status in the physics community and your contribution to the Institute as a member of the Editorial Board of a journal".

Mr. Robert Zarr, Building Environment Division was elected Fellow of the International Thermal Conductivity Conference in recognition of his contributions to the field of thermal conductivity and, in particular, for his work on the development of thermal conductivity standards.

Ms. Mona Baghai Anaraki, a student co-op working in the polymer laboratory in the Building Materials Division.

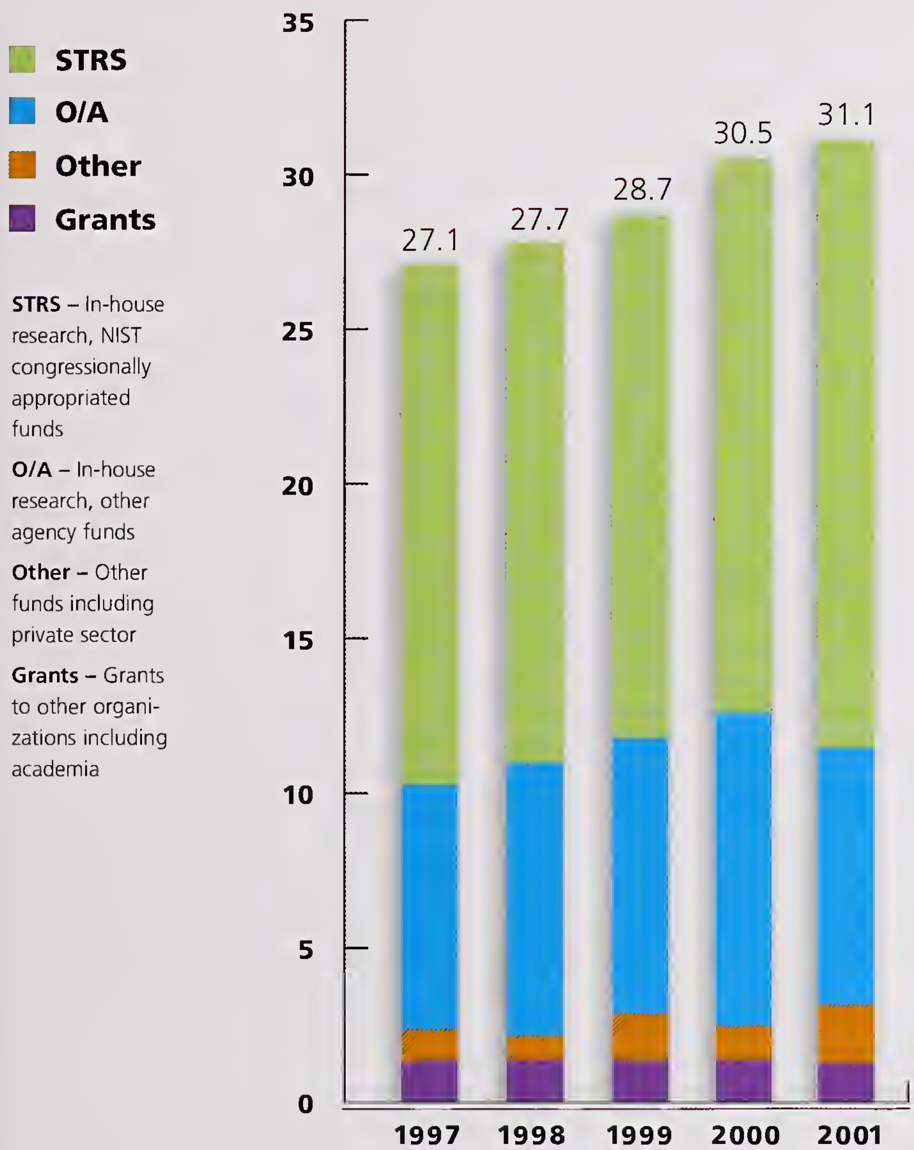
Drs. Chris White and **Chiara Ferraris**, Building Materials Division, took the initiative to make arrangements with NSF for the establishment in BFRL of a Student Undergraduate Research Fellowship (SURF) program. In 2001, 11 undergraduates participated in the program and spent the summer gaining research experience in BFRL.

Dr. Nicholas Carino, Structures Division, was recognized for "sustained and original contributions in advancing the art and science of concrete world-wide" at the Fifth CANMET/ ACI International Conference on Recent Advances in Concrete Technology held in Singapore in 2001. In his invited paper, Dr. Carino reviewed the NIST research that was instrumental in the development of two ASTM standards: one on the maturity method and the other on the impact-echo method.

Dr. Dat Duthinh, Structures Division, has accepted an appointment as an Associate Editor of the *Journal of Structural Engineering of the American Society of Civil Engineers*.

Finances and ORGANIZATION

BFRL Resources 1997-2001 **($ millions)**

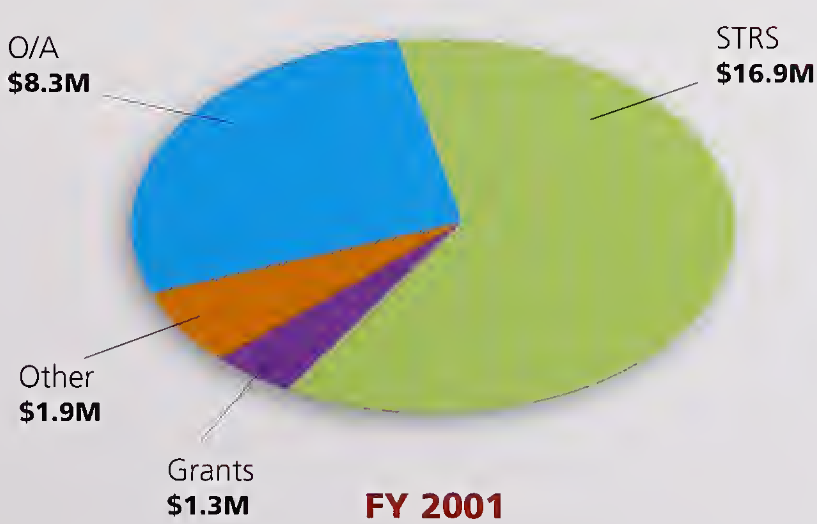


STRS – In-house research, NIST congressionally appropriated funds

O/A – In-house research, other agency funds

Other – Other funds including private sector

Grants – Grants to other organizations including academia



FY 2001

Organizations Funding BFRL's Research

Federal agencies and industry groups, which currently support about one-third of BFRL's overall research, are recognized below:

FEDERAL AGENCIES

- Consumer Product Safety Commission
- Department of Agriculture
- Department of Defense Agencies
- Department of Energy
- Department of Health and Human Services
- Department of Housing and Urban Development
- Department of Interior
- Department of Justice
- Department of Labor
- Department of State
- Department of Transportation
- Department of Treasury
- Environmental Protection Agency
- Federal Emergency Management Agency
- General Services Administration
- National Aeronautics and Space Administration
- National Science Foundation
- Nuclear Regulatory Commission

PRIVATE SECTOR

- Advanced Fire Alarm System Consortium
- Air-conditioning and Refrigerating Technology Institute
- American Association of State Highway & Transportation Officials
- ASTM
- California Energy Commission (CEC)
- Dow Chemical Company
- Dow Corning Corporation
- Interphase/Interface Consortium
- Northwestern University
- NYACOL Nano Technologies
- Building Joint Sealants Consortium
- Virtual Cement and Concrete Testing Laboratory Consortium
- Sleep Product Safety Council
- Trane Company

BFRL Organization

STRUCTURES DIVISION

The **Structures Division** provides leadership for BFRL's Advanced Construction Technology Goal by enabling technology-based innovation to modernize construction. Its programs take an integrated view of process and product innovation. The Division provides science-based performance measurement tools for early industry integration and automation of the construction process to achieve cycle time and life-cycle cost reductions in the delivery of construction projects. It also provides similar tools for early industry adoption of innovative constructed systems with assured safety and performance to achieve life-cycle cost reductions and enhanced public safety for both new and existing construction. The Division's programs emphasize innovative structural materials, components, connections, and systems; modeling and simulation of system performance under extreme wind, fire, earthquake, and blast loads; advanced sensing, imaging, control, and automation technologies; and information representation and exchange protocols to assure interoperability of software and hardware systems.

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BUILDING MATERIALS DIVISION

The **Building Materials Division** performs research to advance construction materials science and technology and disseminates improved techniques and data to make possible more informed decisions about the performance of construction materials. The Division develops technical bases for criteria and standards used to evaluate, select, maintain and improve construction materials including inorganic materials such as cement and concrete, and polymeric materials such as coatings and fiber-reinforced composites. Research is designed to develop fundamental understanding of the relationships among chemistry, microstructure, performance and service life of conventional and high performance concrete, and polymeric materials. The results of this research, often carried out in collaboration with industry via consortia, are helping to revolutionize the technologies.

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BUILDING ENVIRONMENT DIVISION

The **Building Environment Division** provides modeling, measurement and test results needed to use advanced computation and automation effectively in construction, to improve the quality of the indoor environment, and to improve the performance of building equipment and systems. The Division conducts laboratory, field and analytical research on building mechanical and control systems. It develops data, measurement methods and modeling techniques for the performance of the building envelope, its insulation systems. Research includes building air leakage, and release, movement and absorption of indoor air pollutants. The Division develops standard communication protocols for building management systems and performance criteria, interface standards and test methods for the nation's building industry to make effective use of modern computer-aided design hardware, software and data base management systems.

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FIRE RESEARCH DIVISION

The **Fire Research Division** develops, verifies, and utilizes measurements and predictive methods to quantify the behavior of fire and the means to reduce the impact of fire on people, property, and the environment. This work involves integration of laboratory measurements, verified methods of prediction, and large-scale fire experiments to demonstrate the use and value of the research products. Focused research activities develop scientific and engineering understanding of fire phenomena and metrology; identify principles and produce metrology, data, and predictive methods for the formation/evolution of smoke components in flames and for the burning of polymeric materials; and develop predictive methods to enable high-performance fire detection and suppression systems. Through the Division's programs in measurement, prediction, systems integration, and the dynamics of fire and its interactions with the built and natural environment, the division provides leadership for advancing the theory and practice of fire safety engineering, fire fighting, fire investigation, fire testing, fire data management, and intentional burning. Extensive publication and technology transfer efforts facilitate the use of fire research results in practice in the fire communities in the United States. Participation in the codes and standards processes helps to reduce barriers to trade and global markets for U.S. goods and services.

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OFFICE OF APPLIED ECONOMICS

The **Office of Applied Economics** provides economic products and services through research and consulting to industry and government agencies in support of productivity enhancement, economic growth, and international competitiveness with a focus on improving the life-cycle quality and economy of constructed facilities. An area of specialty is working in interdisciplinary teams with engineers and scientists from BFRL and NIST to measure the economic impact of new technologies. The focus of the Office's research and technical assistance is microeconomic analysis. The Office provides information to decision makers in the public and private sectors who are faced with choices among new technologies and policies relating to manufacturing, industrial processes, the environment, energy conservation, construction, facility maintenance, law enforcement and safety. It also develops and conducts prototype training programs in applied economics for scientists and engineers.

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More information ABOUT BFRL

Publications

PUBLICATIONS 2000

A listing of BFRL's publications with indexes for abstracts, authors, and keywords is available as hard copy and on two CD-ROMs. Also, full texts of publications from 1994 to the present are available from BFRL Publications On-line at *http://fire.nist.gov/bfrlpubs/*.

ORDERING INSTRUCTIONS

To order copies of these free publications or to discuss BFRL's research reports, contact Mr. Paul Reneke, BFRL. Information Service, 301-975-6696. *paul.reneke@nist.gov*

Web Site

Additional information on each of the BFRL Goals, staff and organization, highlights, news, software, conferences and workshops, standards activities, opportunities for research collaborations, and much more is available on our web site: *http://www.bfrl.nist.gov/*. For questions or comments relating to the web site, email: *bfrlwebmaster@nist.gov*.

Visit the Laboratory

Potential collaborators are encouraged to visit BFRL when in the Washington area. To schedule a visit, contact:

- Dr. Jack E. Snell, BFRL Director, *jack.snell@nist.gov*, or
- Dr. James Hill, BFRL Deputy Director, *james.hill@nist.gov*.

BFRL Inquiries

Questions about specific programs should be directed to BFRL's Management listed in the Chapter, BFRL Finances & Organization. If you have general questions about BFRL programs or are interested in working with BFRL, contact:

- Dr. Jack E. Snell, BFRL Director, *jack.snell@nist.gov*, or
- Dr. James Hill, BFRL Deputy Director, *james.hill@nist.gov*.

The mailing address for all BFRL personnel is:

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National Institute of Standards and Technology

The National Institute of Standards and Technology was established by Congress in 1901 "to assist industry in the development of technology...needed to improve product quality, to modernize manufacturing processes, to ensure product reliability...and to facilitate rapid commercialization...of products based on new scientific discoveries." An agency of the U.S. Department of Commerce's Technology Administration, NIST's primary mission is to develop and promote measurement, standards and technology to enhance productivity, facilitate trade and improve quality of life. It carries out this mission through a portfolio of four major programs:

- **Measurement and Standards Laboratories** that provide technical leadership for vital components of the nation's technology infrastructure needed by U.S. industry to continually improve its products and services;
- a rigorously competitive **Advanced Technology Program** providing cost-shared awards to industry for development of high-risk, enabling technologies with broad economic potential;
- a grassroots **Manufacturing Extension Partnership** with a network of local centers offering technical and business assistance to smaller manufacturers; and
- a highly visible quality outreach program associated with **the Malcolm Baldrige National Quality Award** that recognizes business performance excellence and quality achievement by U.S. manufacturers, service companies, educational organizations, and health care providers.

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