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TECHNOLOGY ADMINISTRATION

National Institute of Standards and Technology

BUILDING & FIRE RESEARCH LABORATORY

ACCOMPLISHMENTS 1995 - 1996

U.S. DEPARTMENT OF COMMERCE
Secretary, William M. Daley

Technology Administration
Mary L. Good, Undersecretary for Technology

National Institute of Standards and Technology
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The Building and Fire Research Laboratory web site is http://www.bfrl.nist.gov

TECHNICAL PUBLICATIONS

1996 Technical publications of the Building and Fire Research Laboratory are listed in NIST SP838-9 and are available on a CD ROM NIST SP 900.

Left: Fire test in aircraft hanger

Richard N. Wright, *BFRL Director*

In 1995, new construction was $535 billion, 8 percent of the GDP, and provided employment for 6 million persons

Director's Foreword

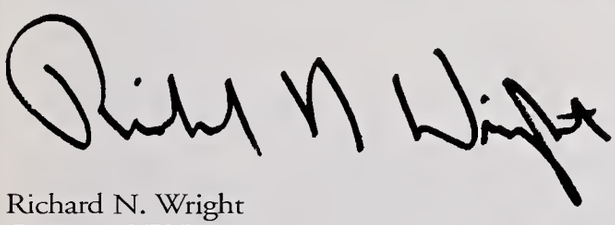
The Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST) has enjoyed interesting and fruitful activities in fiscal years 1995 and 1996.

We are privileged to serve the very important industries of construction. The quality and economy of constructed facilities are important to the competitiveness of all U.S. industries and everyone's quality of life. Consider how: a fire in the headquarters of a company can emperil the viability of the business as well as the lives of the occupants, moisture accumulation and fungus in the walls of a home threaten the durability of the structure and the health of the occupants, and excessive costs of U.S. construction can cause factories and their well paying jobs to move overseas. Each of these examples is addressed by the accomplishments described herein.

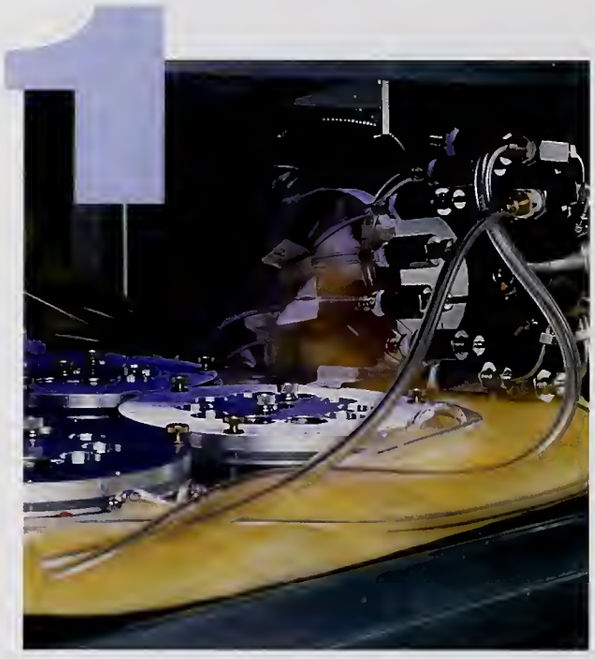
The industries of construction served directly by NIST compose one of the nation's largest economic activities. In 1995, new construction was $535 billion, 8 percent of the GDP, and provided employment for 6 million persons. When renovation of existing facilities is included, annual investment in construction exceeds $800 billion. The industries of construction are diverse. They include: manufacturers of materials and equipment (such as steel, air-conditioners and excavators), planners and designers who integrate materials and equipment from many manufacturers to meet owners' and users' needs, contractors who build the facility on its site, fire safety services and their suppliers, and regulators responsible to federal, state, or local governments for environmental quality and public health, safety and welfare.

In this report we give substantial attention to our involvement in the work of the White House's National Science and Technology Council. The Council is charged to coordinate and focus federal R&D to respond effectively to national needs. We have helped to establish and lead its Subcommittee on Construction and Building (C&B) to coordinate and define priorities for federal research, development and deployment for the industries of construction. C&B is made up of 14 federal agencies which altogether conduct annually over $500 million of construction-related R&D. C&B has worked closely with leaders of the industries of construction to define the vision and goals for improved performance of constructed facilities and construction practices. As described in this report, these are having profound influence on the focus and effectiveness of our work.

The largest and most important parts of this report describe our major accomplishments in 1995 and 1996. We summarize these accomplishments and describe how to obtain detailed information on those important to the reader. We also report progress on making our work more accessible to potential users and collaborators through the Internet, an award-winning video and general interest publications. We hope you find this report interesting and useful. We look forward to working with you and to your comments that will help us improve future reports.



Richard N. Wright
Director, BFRL



Apparatus for measuring photodegradation effects on polymeric material

Prototype Non-Line-of-Sight Surveying System

Kobe earthquake

Mission

The Laboratory's mission is to enhance the competitiveness of U.S. industry and public safety by developing performance prediction methods, measurement technologies and technical advances needed to assure the life cycle quality and economy of constructed facilities.

Programmatic Thrusts

NIST's Building and Fire Research Program focuses on three thrusts: High Performance Materials and Systems for Constructed Facilities, Automation in Construction and Constructed Facilities and Loss Reduction. In addition, BFRL is supporting cooperative private and public activities to streamline regulatory processes for constructed facilities and improve mechanisms for the evaluation and acceptance of innovative products and services.

1 High Performance Materials and Systems for Constructed Facilities,

provides for U.S. leadership in high performance materials and systems for constructed facilities by developing performance criteria and evaluation, measurement and test methods for structural, enclosure, mechanical and fire protection materials, components and systems. These are aimed at opening the marketplace to innovative materials and systems for which product-specific standards do not exist. Attention is given to life cycle performance including functionality, economy, durability, maintainability, recycling and fire safety.

2 Automation in Construction and Constructed Facilities,

provides for U.S. leadership in construction processes and constructed facilities by developing technical bases for integrated open systems for automation and robotics in design, construction, operations, maintenance and renovation. Intelligent systems offer great potential for supporting decisions and providing automatic diagnosis and adaptive control.

3 Loss Reduction,

provides for reduction of U.S. losses of lives, property and production due to fires, earthquakes, extreme winds, explosions and hazardous materials spills. Loss reduction also supports reduction of construction costs and U.S. leadership in products and services for disaster-resistant constructed facilities. BFRL develops criteria for the actions of extreme environments; methods for predicting; measuring and assessing the performance of new and existing facilities; and recommendations for standards providing cost-effective reliability of constructed facilities.

1 Selected Technical Accomplishments

High Performance Materials and Systems for Constructed Facilities

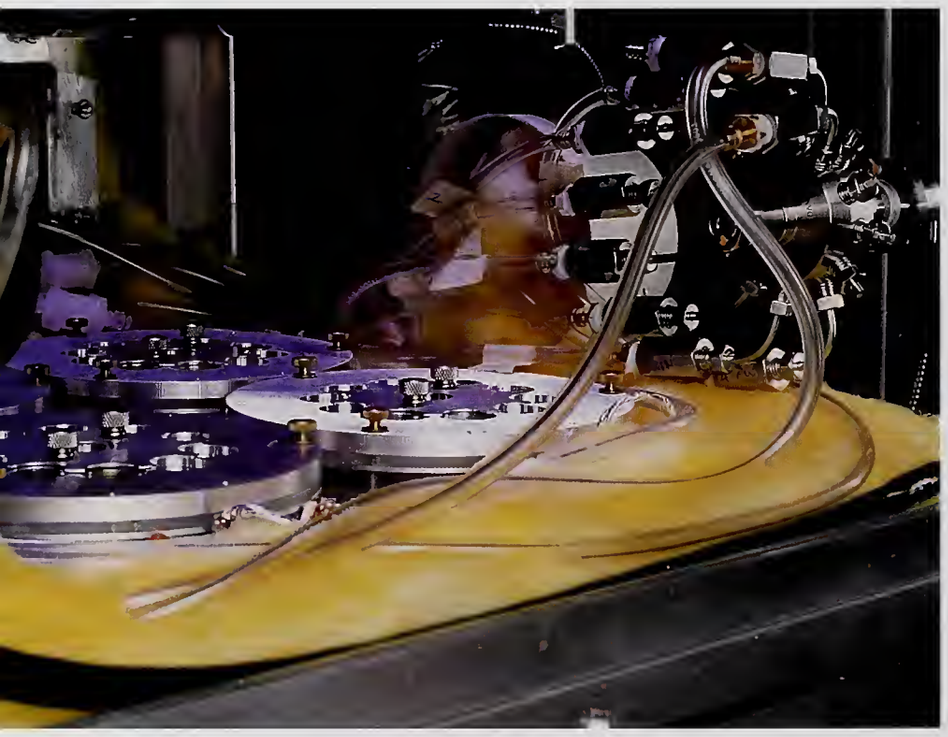
1.1 Photodegradation laboratory established

The loss resulting directly and indirectly from degradation of paints by UV and by water, either alone or in concert, in the U.S. is probably many billions of dollars each year

Based on a concept by BFRL scientist Jon Martin, a new laboratory for assessing photodegradation effects of polymeric material was established at BFRL. The laboratory is equipped with apparatus capable, for the first time, of controlling temperature, humidity and spectral ultraviolet irradiance within rigid performance bounds and equipped with a robotic arm, fiber optic cable and a spectrophotometer for automatically assessing changes in a material's absorptivity and spectral irradiance over time. Ultraviolet radiation degrades almost all organic materials, including paints, plastics and composites. While it is difficult to give a precise figure, the loss resulting directly and indirectly from degradation of paints by UV and by water, either alone or in concert, in the U.S. is probably many billions of dollars each year. The results from the new laboratory will help industry develop improved methods for evaluating the effects of UV on paints and coatings.

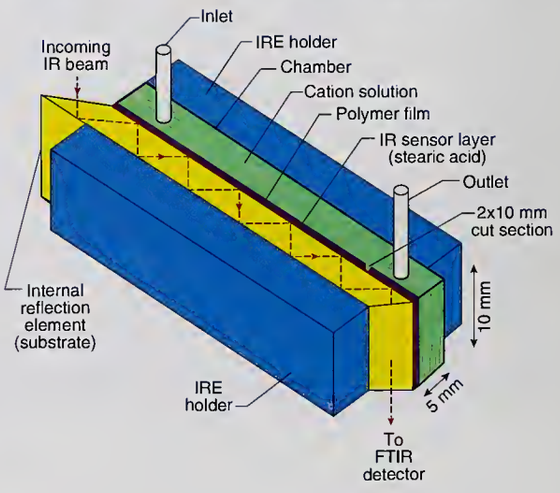
1.2 Advances in coating adhesion

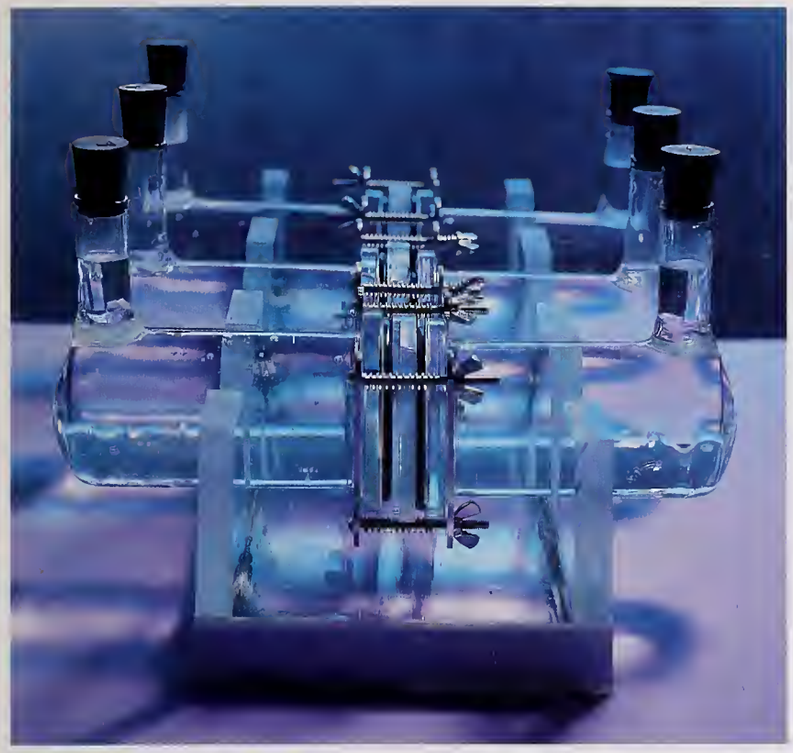
A nondestructive, spectroscopic method was developed by Tinh Ngyen for quantifying thickness of a water layer at a coating/substrate interface. The method is based on a two-layer model derived from evanescent wave theory. The loss of coating adhesion is directly related to thickness of the water layer, and hence to service life of polymeric systems. Failure of paints and coatings often involves loss of adhesion caused by water that reaches the interface with the substrate. The BFRL research has resulted in a new method for studying water at the interface that will help industry develop improved methods for evaluating the effects of moisture accumulating at the paint/substrate interface on factors affecting the adhesion of paints and coatings.



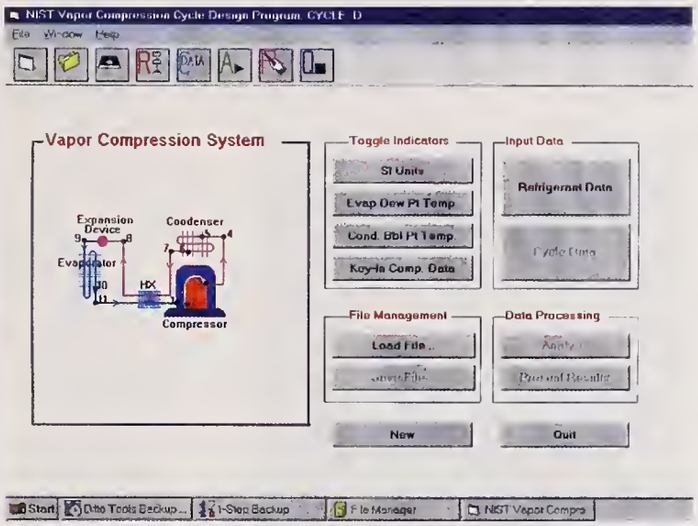
Apparatus for measuring photodegradation effects on polymeric material

Experimental Setup for Measuring Metal Ions at the Polymer / Substrate Interface





Test rig for measuring chloride diffusivity in concrete



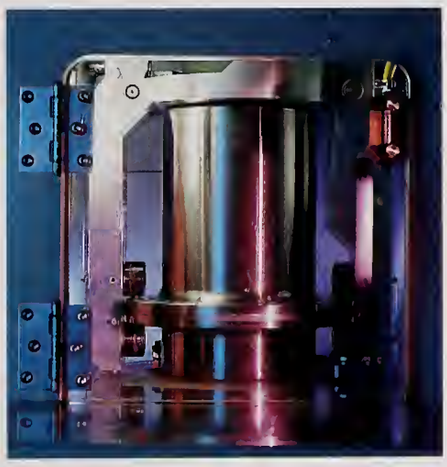
Cycle_D Screen

1.3 Chloride diffusivity of concrete prediction model

For the first time, a model has been developed that can predict chloride diffusivity of concrete from fundamental principles, based on models of the microstructure ranging from nanometers to hundreds of millimeters. Further development and validation of this model will enable the predicted chloride diffusivity to be incorporated into the design stage of concrete materials selection. Research engineer Dale Bentz expects that the model will help highway engineers design reinforced concrete bridges that will have longer lives. This could be of great economic importance since hundreds of thousands of U.S. bridges are in need of repair, rehabilitation or replacement.

1.4 State-of-the-art asphalt laboratory established

Under the management of James Pielert, the American Association of State Highway and Transportation Officials (AASHTO) Materials Reference Laboratory (AMRL) has established a state-of-the-art asphalt laboratory which includes testing equipment developed in the Strategic Highway Research Program. The new equipment includes a dynamic shear rheometer, bending beam rheometer, pressure aging vessel, and a gyratory compactor. The unique equipment in this laboratory will subject highway materials to tests designed to evaluate durability. The $150 million Strategic Highway Research Program will lead to longer lasting asphalt highways. Eighty per cent of new highways are constructed of asphalt.

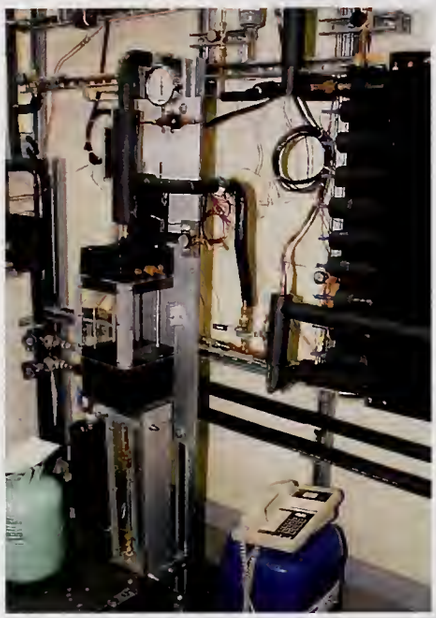


Gyratory compactor for hot mix asphalt

1.5 Model for simulating vapor compression cycles

Piotr Domanski has developed a model for simulating vapor compression cycles, CYCLE_D. Because of its generality and friendliness, the model can be used in diverse applications such as preliminary refrigerant screening, system design and education and training. The model can simulate systems using up to 38 different refrigerants and refrigerant mixtures with up to five components. The Windows-based front end allows easy selection of the working fluids, operating conditions and several modeling options. The model is now available through the NIST Office of Standard Reference Data, telephone (301)975-2208, as Data Base 49 and has been distributed to more than 60 customers.

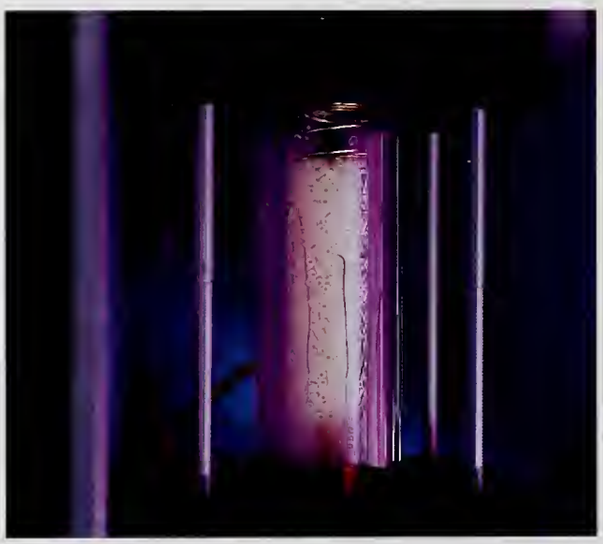
1.6 Patent on heat pump performance enhancing device



Distillation column, capable of changing refrigerant mixture composition in heat pumps

By controlling the mixture composition, the heat pump capacity can be modulated in response to changes in the outdoor temperature

BFRL has received a patent on a device to improve the cold weather performance of residential and light commercial air-source heat pumps. The device was invented by Peter Rothfleisch to solve the problem of a heat pump's inability to pump enough heat to match the heat loss of a dwelling on a cold day. Heat pumps are normally equipped with auxiliary electric resistance heaters, which are turned on automatically when needed. This resistance heating is expensive for the homeowner and often causes a peak demand problem for the utility. The patented device is a distillation column that when utilized with a zeotropic refrigerant mixture is capable of changing the refrigerant mixture composition. By controlling the mixture composition, the heat pump capacity can be modulated in response to changes in the outdoor temperature. Thus, the distillation column enables the heat pump to maintain acceptable performance



Detail of distillation column

over a much wider temperature range and reduces the need for resistance heating. In tests to date in the BFRL laboratory, a heat pump with the distillation column has shown a 12% increase in capacity, a 9% decrease in peak energy demand and an estimated reduction in seasonal energy demand of 5%. The potential improvement with other refrigerant mixtures is greater. An added benefit of changing the refrigerant composition is that a warmer discharge air temperature can be delivered to the conditioned space. Leading U.S. manufacturers have visited and taken a keen interest in the development formulated from environmentally acceptable components.

1.7 Advanced vacuum insulation panels

BFRL completed the testing of two types of advanced insulation products. Hunter Fanney, working under a cooperative research and development agreement with Aladdin Industries, tested three metal-clad vacuum insulation panels using a calorimetric technique. In addition to the experimental work, a finite element parametric study was conducted for Aladdin Industries to evaluate various design options. Working cooperatively with Lawrence Berkeley Laboratories, Krypton and Xenon gas-filled panels were tested for a range of environmental conditions. These gas-filled panels had a thermal resistance five times greater than that of glass-fiber insulation. The results of this work were presented at the International CFC and Halon Alternative Conference and the Building Environment and Thermal Envelope Council Conference. The first application of this technology will be in applications where space is the first priority such as the walls of refrigerator-freezers. The U.S. Environmental Protection Agency has estimated that by incorporating this technology in all major refrigerator-freezer units, $1 billion of electrical energy would be saved on an annual basis.

The photovoltaic solar water heating system has provided over 60 percent of the energy required to heat water for a family of four since it became operational in June 1995

Top: Solar collection array
Bottom: Solar powered domestic water heater

1.8 Photovoltaic solar water heating system

A photovoltaic solar water heating system, based on a patent issued to Hunter Fanney and Peter Dougherty in March 1994, has been constructed and monitored at BFRL. The system has provided over 60 percent of the energy required to heat water for a family of four since it became operational in June 1995. The system avoids durability issues associated with solar thermal hot water systems such as freezing, loss of the heat transfer fluid and the failure of moving parts. A detailed computer simulation model has been developed to predict the performance of this novel system for various geographical locations and system designs. A second system was installed at the Florida Solar Energy Center in Cocoa Beach, Fla., to showcase the technology at a premier solar energy laboratory, collect additional experimental data to validate computer simulation models, and determine the performance of the system under different meteorological conditions. The system became operational on December 1, 1995. Experimental data was collected for 12 continuous months. A third system has been installed at the Sugarlands Visitor Center of the Great Smoky Mountains National Park near Gatlinburg, Tenn. There are approximately 90 million residential water heaters currently in use within the U.S. Approximately 7.5 million units are sold each year. A 5 percent market penetration would result in sales in excess of 4.5 million photovoltaic solar water heaters representing a market value of approximately $8 billion. If it is assumed that all of the photovoltaic solar water heating systems were used to supplement electric water heaters, the annual savings to electric utility consumers would be $1.5 billion.

1.9 Improved thermal conductivity measurement capability

The Materials Reliability Division in Boulder, Colo. transferred two thermal conductivity apparatuses, a low temperature and a high temperature guarded hot plate to BFRL. Both pieces of equipment determine the steady-state thermal transmission properties of heat insulators at temperatures significantly different from room temperature. The low temperature apparatus is cooled with liquid nitrogen and can attain low temperatures of 100K. The high temperature apparatus has been refurbished and can attain an upper temperature of 675K. The low temperature plate has already been used to extend the temperature range of standard reference material (SRM) 1450 b (high-density insulation board) and SRM 1451 (low-density insulation blanket) down to 100K. In the future it will be used to extend the low temperature range of a third SRM, 1450 c and to characterize other semi-rigid thermal insulation materials for their conductivity dependence on temperature, pressure and humidity. The high temperature plate will be used to produce NIST's first high temperature SRM.

Robert Zarr checks the thermal conductivity apparatus

1.10 Implementation of strategic highway research program technology

The BFRL American Association of State Highway and Transportation Officials Materials Reference Laboratory (AMRL) is supporting implementation of results from the Strategic Highway Research Program (SHRP). New technology developed by SHRP is currently being implemented by the Federal Highway Administration (FHWA), state transportation departments and the private sector. AMRL has assisted the AASHTO Subcommittee on Materials in processing over 50 standard methods for testing materials used in highway standards. AMRL laboratory inspection and proficiency sample programs are being modified to include new asphalt binder and bituminous concrete standards. These materials are used in almost 80% of the nation's highways.

There are over 100 laboratories using these new AMRL services which will improve the acceptance and precision of the new test methods.

1.11 Model for assessing the economics of new construction materials

BFRL's Mark Ehlen is completing an alpha version of BridgeLCC, user-friendly software that computes the life-cycle costs of federal, state, and county highway bridges. Based on an economic method recently developed by Ehlen and Harold Marshall, BridgeLCC helps state bridge engineers and project planners determine the cost effectiveness of highway bridges made of new construction materials that are lighter, easier to install, more durable, and corrode less. BridgeLCC gives state departments of transportation an evaluation tool to help them reduce the life-cycle cost of maintaining the nation's highway system by building new bridges (and repairing existing bridges) using new technology materials.

1.12 Fault Detection and Diagnostics (FDD) on Variable-Air-Volume (VAV) Air Handling Systems

Working with the International Energy Agency (IEA) Annex 25 committee, George Kelly and John House made significant progress in 1995 in developing a new methodology for performing fault detection and diagnostics (FDD) on Variable-Air-Volume (VAV) air handling systems. The method uses residuals of system variables to quantify the dominant symptoms of different faults. Idealized steady-state patterns of the residuals are then defined for each fault mode of operation and the relationship between the dominant symptoms and the faults is learned by an Artificial Neural Network (ANN) using the back propagation algorithm. The trained neural network is then used for FDD applications in real time. Two papers on this research were presented at the ASHRAE Winter Meeting in Atlanta in February 1996 and a third paper is under development. BFRL also led two joint evaluation exercises among Annex 25 members to test and evaluate a variety of different FDD methods for VAV systems. Johnson Controls is now incorporating this methodology into its standard air handling unit controller that is sold to 10,000 customers per year.

Variable-Air-Volume (VAV) Air Handling System

1.13 MOIST, a personal computer program that provides guidelines for controlling moisture in building envelopes

Using BFRL's large calibrated hot box, Douglas Burch and Robert Zarr completed an extensive laboratory verification of MOIST, a personal computer program, developed in BFRL, that provides building practitioners with the means to develop appropriate guidelines for controlling moisture in building envelopes. MOIST has been distributed to over 900 individuals and is currently being used by manufacturers of building materials, moisture consultants, universities and research laboratories. Prior to the development of MOIST, moisture control guidelines were, for the most part, unsupported by valid technical analysis. The agreement between predicted values by MOIST and the experimental results was within one percent moisture content for most of the wall specimens. The results of this study were published in Building Science Series 173 *Heat and Moisture Transfer in Wood-Based Wall Construction: Measured Versus Predicted.*

MOIST was extended to include attics (and cathedral ceilings). The revised model performs a heat and moisture balance on an attic space as a function of time of year. The revised model includes: storage of heat and moisture within construction materials, thermal radiation exchange among the interior surfaces, variable attic ventilation rates as a function of wind speed and temperature difference, and variable stack-effect air flows from the house into the attic. The relative humidity in the house below is permitted to float and is calculated from a moisture balance on the whole building with the effective leakage area and moisture generation rate as input. The model is currently being used to develop guidelines to control moisture in the attics of site-built homes and manufactured homes for various climatic regions.

If the use of MOIST could eliminate moisture accumulation in 20 percent of the affected roofs and walls in the U.S., an annual savings of $30 million per year would result.

NIST's large calibrated hot box

1.14 Indoor air quality commissioning program

Andrew Persily and Stewart Dols have developed and implemented an indoor air quality commissioning program in the recently constructed Nuclear Regulatory Commission Building in Rockville, Md. The products of this study included a unique data set of building air quality parameters during and after construction, and increased understanding of a number of issues that should be addressed in planning future indoor air quality commissioning efforts. The commissioning protocols developed in this project will contribute to the development of consensus standards for indoor air quality evaluations of new and existing buildings through ASHRAE and ASTM. In addition, they are serving as key inputs to the U.S. Department of Energy effort to add an indoor air quality component to their North American Energy Monitoring and Verification Protocol (NEMVP). The NEMVP is being used to assess the impacts of energy conservation measures in existing buildings, and it is currently being expanded to address the indoor air quality benefits of these measures.

Nuclear Regulatory Commission building, Rockville, Md.

1.15 Residential indoor air quality

BFRL has conducted airflow and indoor air quality computer simulations to assess the impact of HVAC technology on residential indoor air quality. Steve Enherich has examined the potential for using innovative modifications of conventional forced-air systems to reduce indoor pollutant levels. He found that residential ventilation systems with outdoor air intake can potentially reduce indoor concentrations of volatile organic compounds by as much as 70% compared with conventional forced-air systems. Similarly, these systems can reduce carbon monoxide concentrations due to emissions from ovens and unvented space heaters by as much as 40%. These results are being considered within the Consumer Product Safety Commission (CPSC) for potential actions on the part of that agency, such as suggestions for building code changes. In addition, the results of this effort served to support some of the changes in the revision of ASHRAE Standard 62-1989R.

It was found that residential ventilation systems with outdoor air intake can potentially reduce indoor concentrations of volatile organic compounds by as much as 70% compared with conventional forced-air systems

1.16 Office buildings air leakage and indoor air quality

Steve Enherich has conducted a study in which the energy consumption due to air leakage in U.S. office buildings was estimated. The results of this study show that air leakage accounts for roughly 15% of the heating load in office buildings nationwide, with a higher percentage in recently constructed buildings. These results, and the methodology developed to obtain them, will be used to study approaches to increasing the energy efficiency of office buildings through increasing envelope air tightness and better ventilation system controls. In addition, these and future results will be used in the development of an air tightness standard for federal buildings by the U.S. Department of Energy. Engineers have also developed a new ASTM provisional standard on the use of indoor carbon dioxide concentrations to assess building ventilation and indoor air quality. Based on previous research conducted at BFRL, this document will increase the reliability of field measurements and interpretations of indoor carbon dioxide concentrations.

1.17 Smoke toxic potency standard

Most fire victims die from smoke inhalation rather than burns. Recently, ASTM and the National Fire Protection Association have adopted as standards the BFRL-developed method for measuring the toxic potency of smoke from burning materials (ASTM E-1678 and NFPA 269). These are the first validated and quantified methods of this property. Of high importance is the fact that the method, combined with contextual analysis, shows there is little distinction among most building and furnishing products.

Cone colormeter being used to measure effect of fire retardants

Therefore, this test method will relieve product manufacturers from an unnecessary regulatory constraint, easing the use of new, high performance materials in these products.

1.18 Aircraft fire suppressants

With the key fire suppressant for in-flight aircraft fires, halon 1301, no longer in production, both the Department of Defense (DoD) and the commercial aviation industry need a replacement. Under sponsorship of the DoD and the Federal Aviation Administration, a team of NIST scientists have provided the technical basis leading to selection of the optimal currently available chemical, HFC-125, and generated practical information for designing retrofit systems that will come closest to the effectiveness of halon 1301. These findings have been published as *Fire Suppression Systems Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations*, NIST Special Publication 890, 2 volumes, 1415 pages, November 1995, Richard G. Gann, ed. In particular, the results on dynamics of fire suppressant release in engine nacelles, which provides the understanding of the fire bottle emptying process, the two-phase pipe flow, and the character of the spray necessary to select an alternative to halon 1301 and design a meaningful certification process for engine nacelle fire protection applications, have already been adapted by the Boeing Commercial Airplane Company for the 777 and by the US Navy.

1.19 Fire detection systems for high spaces (aircraft hangars)

Current fire protection for aircraft hangars is designed to save the building. However, the high cost of modern aircraft makes it highly desirable to protect the contents as well. Under the sponsorship of the Naval Facilities Engineering Command (NAVFAC), Kathy Notarianni of BFRL and Joseph Gott of NAVFAC led a government/industry team that determined how new approaches could lead to quicker response to a smaller fire, thus reducing damage to adjacent planes. The full-scale and laboratory-scale data sets are the most comprehensive and precise ever generated for high-ceiling enclosures and is already providing the commercial fire protection community and the government with the knowledge needed to upgrade fire detection and suppression systems for these large buildings.

Left: Fire tests in aircraft hanger

1.20 Effective fire retardant for many polymers

Nearly all polymer products must meet flammability requirements in addition to satisfying the performance desires of consumers. For most polymers, fire performance is met with fire retardant additives, many of which are based on bromine and chlorine. Because of possible environmental and recycling requirements, the search for alternatives to halogenated fire retardants is a subject of high concern to the plastics industry.

Takashi Kashiwagi and Jeffrey Gilman of the BFRL Fire Science Division and Sergei Lomakin of the Russian Academy of Sciences have been studying mechanisms for reducing the burning rate of polymers. They have now found that the combination of silica gel and potassium carbonate, two common chemicals, is an effective fire retardant for a wide range of high-use polymers, including nylon, polypropylene and cellulose.

The rate of heat release, the most important property in determining fire hazard, is reduced by up to a factor of three, with no significant increase in smoke or carbon monoxide production. Further research is under way to understand better how this formulation affects such a wide range of materials. The results have been presented to the Society for the Advancement of Material and Process Engineering.

Selected Technical Accomplishments

1.21 Simulation of polymer behavior during fire exposures

Much industrial design of new materials is now accomplished using molecular modeling of the chemicals. Over the past few years, BFRL chemist Marc Nyden and co-workers have developed such a capability for the response of simple polymeric materials to fires. Now, under a cooperative agreement with Biosym Technologies, the leading commercial firm in molecular modeling, Nyden has unified the BFRL model with Biosym's capability to encompass most commodity plastics. This new capability enables the polymer industry to develop novel, less flammable materials while preserving their principal market and processing properties.

1.22 Refrigerant flammability

In order to minimize the environmental impact of refrigerants, alternative chemicals are required that do not deplete the earth's stratospheric ozone. Many efficient new alterative refrigerants are combinations of flammable and nonflammable components. To optimize the performance of these mixtures while maintaining a fire-safe final product, precise and accurate measurements of flammability are needed. Carole Womeldorf and William Grosshandler of the BFRL Fire Science Division, under sponsorship of the Air Conditioning and Refrigeration Institute, have developed a new test method for obtaining quality fire performance data for these weakly flammable refrigerants. An opposed flow burner produces an explicit value of the lean flammability limit for a refrigerant/air mixture as a function of the initial gas temperature and pressure. It thus eliminates the need to distinguish between a non-propagating flicker and a weak, but self-sustaining flame, as is required in the conventional method. Initial results indicate that the precision of this method may be an order of magnitude improvement over previous methods.

Stabilized flame for measuring refrigerant flammability

1.23 Standards for testing high-strength concrete

Problems have arisen in testing high-strength concrete using current ASTM standards. In cooperation with the National Ready-Mixed Concrete Association, BFRL has carried out research to isolate those testing conditions that have statistically significant effects on the measured compressive strength of high-strength concrete test specimens. One of the significant factors is the end preparation. It has generally been thought that the capping compounds used to produce flat ends must be at least as strong as the concrete being tested. However, research results have shown that this is not necessary provided the caps are thin. Another area of dispute that has been addressed in the research deals with the use of 100 mm diameter cylinders instead of the traditional 150 mm diameter specimens. The smaller specimens will allow the use of existing testing machines to test high-strength concrete. The research has demonstrated that the two specimen sizes yield comparable strength values provided a new procedure is used to prepare the smaller specimens. The results of this cooperative work provide the basis for proposed changes to the ASTM standards.

The research has demonstrated that the two specimen sizes yield comparable strength values provided a new procedure is used to prepare the smaller specimens.

1.24 Test methods for FRP reinforcement

A major obstacle to the use of fiber-reinforced plastic (FRP) bars for concrete reinforcement is the lack of standard specifications and test methods. Research at BFRL is supporting the development of these vital standards. The two important mechanical properties of FRP bars needed by a designer are tensile strength and modulus of elasticity. Unfortunately, standard test methods developed for testing steel bars are not applicable. Traditional friction gripping devices damage the ends of the bars and result in premature failures. BFRL researchers, in cooperation with a guest worker from Brazil, have developed a simple method for performing tensile tests. The novel system uses an inexpensive metal tube and a fast-setting, high-strength gypsum-based mortar to encapsulate the ends of the bars so that they can be gripped by ordinary friction grips. The traditional method for measuring the elastic modulus is by instrumenting a tensile test specimen so that its elongation is measured as it is being loaded. This approach is time consuming and prone to experimental errors. BFRL researchers have demonstrated that the elastic modulus can be determined more reliably by using a nondestructive test method based upon measuring the resonant frequency of a specimen after it has been impacted with a small hammer. Results have shown that the measured values from the nondestructive test method have less dispersion than the traditional method and the results are obtained in a fraction of the time.

NIST researchers have demonstrated that the elastic modulus can be determined more reliably by using a nondestructive test method based upon measuring the resonant frequency of a specimen after it has been impacted with a small hammer.

1.25 Fire fighter protective clothing

BFRL began a study of the performance of fire fighter protective clothing. Based on historical information and new laboratory measurements, a greater understanding of fire fighter burn injuries was developed. A report, NISTIR 5804, *Fire Fighter's Protective Clothing and Thermal Environments of Structural Fire Fighting,* by Randall Lawson, was issued detailing the findings of this research. Working with protective clothing manufacturers, the Federal Emergency Management Agency (FEMA), State Fire Marshals, and arson investigators, BFRL developed a new guide for the selection of personal protective clothing and equipment for emergency managers, investigators and inspectors.

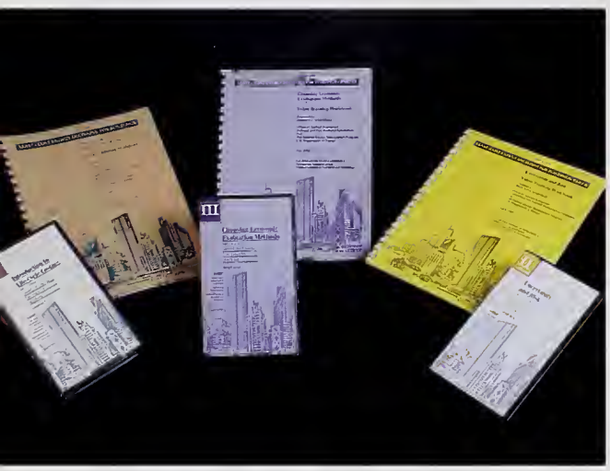
Fire test technicians in protective clothing prepare to extinguish a test burn

2

Selected Technical Accomplishments

Automation in Construction and Constructed Facilities

2.1 Videos for making least-cost energy decisions for buildings



Video and workbooks in the series *Least-Cost Energy Decisions for Buildings*

A set of three training videos, developed under the direction of BFRL economist Harold Marshall, helps energy managers make least-cost energy decisions for buildings. The first video in the series titled *Least-Cost Energy Decisions for Buildings* is *Life-Cycle Costing*, a 60-minute program that helps users learn how to compute, apply, and interpret life-cycle cost measures for decisions affecting energy consumption in buildings. The second, *Uncertainty and Risk*, is a 36-minute video that provides the fundamentals for measuring, describing and interpreting uncertainty and risk in economic evaluations of energy conservation projects. *Choosing Economic Evaluation Methods* completes the series. It provides 35 minutes of instruction on how to select among economic methods such as life-cycle costing and the savings-to-investment ratio when evaluating energy conservation projects. Supporting workbooks provide expanded descriptions of the technical material, a glossary of technical terms used in the videos and exercises in applying economic methods. Over 2,000 copies of the videos and workbooks are in circulation.

2.2 Historic importance of buildings rating system

A rating system for evaluating the relative historic importance of buildings in the GSA Public Buildings Service (PBS) portfolio (nearly 1,000 buildings) was developed and implemented in the software HIST (Historic Importance Software Tool). HIST is compatible with software currently used by PBS managers to collect detailed data on the historic characteristics of the PBS buildings. According to developers Barbara C. Lippiatt and Stephen F. Weber, HIST integrates these data into a comprehensive, consistent and reliable rating system to measure the combined historic significance at several levels of building detail. HIST is used by GSA headquarters and regions for ranking and analyzing the PBS building inventory, and as the basis for budget planning and allocation.

Alexander Hamilton U.S. Custom House in New York, NY

2.3 BACnet

BACnet booth at the ASHRAE Show

In June 1995, ASHRAE Standard 135-1995, BACnet - A Data Communication Protocol for Building Automation and Control Network, was approved by ASHRAE. Since the beginning of the development of ASHRAE SPC 135 in January 1987, Steve Bushby has been a major contributor to the development of this protocol, which will enable products of different manufacturers of energy management and control systems (EMCS) to "interoperate" together. This standard should significantly reduce the cost of interconnecting control systems from different manufacturers, and will provide the basis for the future integration of different building services, such as energy management, fire detection, security and building transportation. BACnet is now being demonstrated in the Philip Burton Federal Office Building in San Francisco, the largest federal office building west of the Mississippi River. If this demonstration is successful, future plans include adding BACnet control systems to 48 other federal buildings in California. By linking these buildings using BACnet, the federal government will be able to purchase electricity for all of these buildings in one block, qualifying for industrial rates. This will reduce electric utility costs for GSA in California by 47%. This project is intended to be a model for GSA-owned and GSA-operated buildings nationwide.

2.4 Non-Line-of-Sight (NLS) surveying system

The first-ever tests of a prototype Non-Line-of-Sight (NLS) surveying system were recently conducted at NIST by BFRL in a collaborative effort with MIT Lincoln Laboratories. The objective of the research, which is part of the NIST Initiative in Construction Automation, is to develop a standardized system by which the real time position and orientation of any object on a construction job site may be determined, irrespective of the presence of intervening obstacles, including building walls and roofs. Preliminary results show that it is possible to locate, via time-of-flight measurements, the position of a "roving" receiver beyond a one-meter-thick reinforced concrete wall, or beyond several brick and masonry block walls to within an accuracy of 1m over a 100 m transmission path with a repeatable resolution of 200 mm. Significant improvements in accuracy are expected to be realized in FY97.

Prototype Non-Line-of-Sight surveying system

3

Selected Technical Accomplishments

Loss Reduction

3.1 Fire on the Web

"Fire on the Web" is a new web site developed by Glen Forney in 1996 to complement the FASTLite fire modeling software. This web site, available at http://www.bfrl.nist.gov/fire.html, provides information for various fire tests that can be used with FASTLite to assist in model runs. Some of this information includes: still pictures of fires with the associated heat release rate, computer movies of fires and data sets that can be downloaded and run with the FASTLite software. This site is accessed over 6,000 times a month by people from over 40 countries.

Fire on the Web

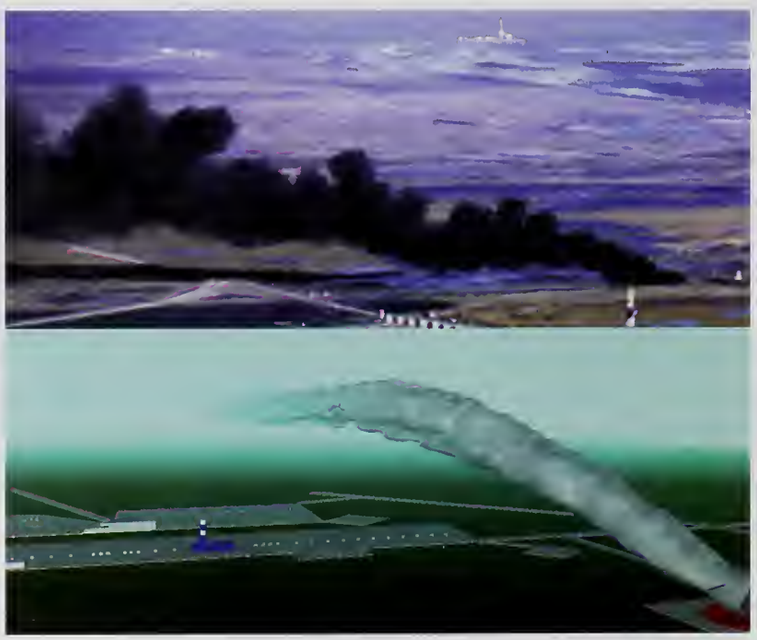
3.2 FastLite

The BFRL Fire Modeling and Applications Group developed a new a user friendly software package, FASTLite, which builds on the core routines of previous computer fire models FPEtool and CFAST. In the first three months since its introduction in May 1996, 2,260 copies of the software package have been distributed free of charge either on CD-ROM or as downloads from the BFRL web site. This fire model calculates fire phenomena for use by building designers, code officials, fire protection engineers and fire-safety related practitioners. FASTLite includes a number of tools of use to the fire safety practitioner including models for heat and smoke detector activation, sprinkler suppression and atrium temperatures.

3.3 Prediction of smoke spread from large fires in Alaska

Working with EMCON Alsaka Inc. and the State of Alaska, Kevin McGrattan has completed a second generation model for predicting downwind smoke concentrations produced from a large oil fire in a region of complex terrain. The model has been used in conjunction with spill response drills conducted to plan for intentional burns in Port Valdez, Prince William Sound and the North Slope. The previous flat terrain version of the model has been compared with data from three large-scale experiments and found to be good enough to be useful for making decisions on whether intentional burning is a viable method for cleaning up a spill.

Top: Aerial photograph of experimental crude oil burner, North Slope, Alaska
Bottom: View of simulated plume of the crude oil burn, as seen from upwind



3.4 Predicting the performance of industrial fire protection systems

Working with the three major U.S. automobile manufacturers and the National Fire Protection Research Foundation, BFRL has completed a first-generation computer model based on large eddy simulation technology to predict the interaction of sprinklers, draft curtains and vents in industrial warehouse and

manufacturing facilities. The model will be subjected to verification testing in FY 97 when a series of large-scale tests funded by industry will be conducted to collect performance data. Using the results of these tests a second-generation model is planned.

3.5 Software for cost-effective compliance with the Life Safety Code

BFRL economists Stephen Weber and Barbara Lippiatt have developed software, called ALARM (Alternative Life Safety Analysis for Retrofit Cost Minimization), that helps building managers and fire safety engineers achieve cost-effective compliance with the widely used Life Safety Code of the National Fire Protection Association (NFPA). The software currently supports analysis of health care occupancies and future versions are planned for other building occupancies. Through the equivalency provision of the code, ALARM implements a goal-oriented approach to compliance. The software generates a set of alternative code compliance strategies and their estimated construction costs. Engineering judgment is then applied to select the most appropriate strategy based on both cost and design considerations. The optimization method used in ALARM has been field tested in 89 hospitals (17,898 beds) since 1981. The least-cost solution identified by the software was on average 41 percent less expensive than the prescriptive solution. This represents a potential cost savings of $2,116 per bed or over $37 million. More than 300 copies of ALARM have been sold by the NFPA.

3.6 Fire spread through windows

As a result of on scene investigations of the post-earthquake fires in housing developments in the Northridge California area, by William Walton, fire spread through windows was identified as a primary cause of loss. Suggested mitigation strategies that could be implemented by residents under emergency conditions to substantially increase the resistance to fire spread from structure to structure have been evaluated. Strategies as simple as placing aluminum foil over window panes can substantially increase the resistance to fire spread. The findings of this study will be made suitable for public information bulletins.

Building evacuation planning

3.7 Fire Data Management System (FDMS) data base available on Internet

The first generation of a fire database including data from the Cone Calorimeter test (ASTM 1354/ISO 5660) and Eurefic Corner tests (NT 025/ISO 9705) along with several full-scale tests including 3 room, 4 room, and multi-story structures has been made available over the Internet using the Fire Data Management System (FDMS) data base format developed by BFRL's Fire Modeling Applications Group. This growing central data base of fire related data, made up of contributions from NIST and other fire laboratories, has been established to facilitate the use of models and verification of test results from standard measurement apparatus.

3.8 Building evacuation manual for disabled

Emergency Procedures for Employees with Disabilities in Office Occupancies was produced in English, Spanish and Braille. The booklet developed by Richard Bukowski is being distributed by the U.S. Fire Administration. This booklet helps building owners and managers to develop cost effective plans that comply with the requirements of the Americans with Disabilities Act.

3.9 New mechanisms of carbon monoxide formation in fires

Most fatalities from building fires result from the breathing of toxic combustion products and not burns, and the principle chemical species responsible for fire deaths is carbon monoxide (CO).

William Pitts has led a team in developing the first predictive capability for the amount of CO formed. Fatal levels of CO are mostly formed during intense, flashed-over enclosure fires, where insufficient air enters the enclosure to ensure complete combustion. Pitts combined the results of in-house experiments and modeling with findings from BFRL-sponsored research at Harvard University, Virginia Polytechnic Institute and State University and the California Institute of Technology to identify four distinct mechanisms for the formation of CO in these enclosure fires. They are (1) quenching of a turbulent fire plume upon entering a rich upper layer; (2) mixing of oxygen directly into a rich, high-temperature upper layer with subsequent reaction; (3) pyrolysis of wood in a high-temperature, vitiated environment; and (4) approach to full thermodynamic equilibrium combustion product distributions in rich, high-temperature upper layers. These results have been incorporated into an algorithm which allows fire researchers to determine which mechanisms are responsible for the generation of CO for a given fire scenario and to develop estimates for the amounts of CO which will be generated. It is now clear that small-scale toxicity tests on samples of furnishings and wall coverings alone are not sufficient for characterizing the toxicity of smoke from real fires, and regulation of products based on such tests is unlikely to improve fire safety. On-going efforts are aimed at characterizing the fate of combustion gases once they exit the room of fire origin.

Scale model experiments to measure generation of carbon monoxide

3.10 Quantitative soot data in time-varying flames

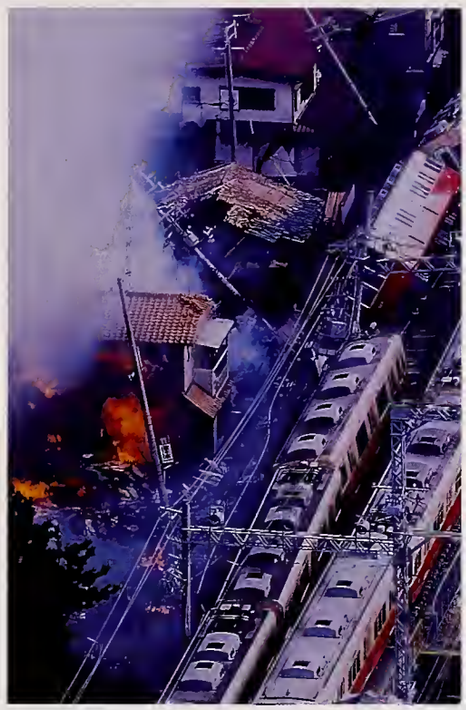
The first quantitative soot data in time-varying flames for different fuels have been obtained. These data may represent the most important advance in soot measurements in the last 20 years. The results become the benchmark for testing for soot production models. The paper *Laser-Induced Incandescence Measurements of Soot Production in Steady and Flickering Methane, Propane, and Ethylene Diffusion Flames* by C.R. Shaddix and K.C. Smyth, has been submitted to *Combustion and Flame.*

These data may represent the most important advance in soot measurements in the last 20 years

Diffusion flame

3.11 Kobe earthquake studied

The January 17, 1996, Hyogoken-Nanbu earthquake of magnitude 7.2 in JMA scale (Mw = 6.9), which struck Kobe, Japan, and its surrounding area, was the most severe earthquake to affect that region in this century. The earthquake resulted in more than 6,000 deaths and over 30,000 injuries. Fires following the earthquake incinerated the equivalent of 70 U.S. city blocks. They together destroyed over 150,000 buildings and left about 300,000 people homeless. The economic loss as a result of this earthquake is estimated to reach $200 billion.



Kobe earthquake

The postearthquake investigation was conducted under the auspices of the Panel on Wind and Seismic Effects of the U.S.-Japan Program in Natural Resources to observe, document and compile important lessons from this earthquake that can be used to mitigate the potentially tragic impact of future earthquakes on modern urbanized communities. The study team's report summarizes the information collected during the investigation and recommends research and improved practices to reduce earthquake loss in the United States.

Kobe earthquake

3.12 High-rise building fire safety problems solved

The results of BFRL studies of elevator evacuation of office buildings and air traffic control towers during fires have been utilized by industry to deal with the unique challenge of high-rise building fire safety in the design of the Las Vegas Stratosphere Hotel and Casino. This facility, which includes a 350-meter tall tower with hotel and amusement rides, does not fit into any of the existing occupancy classes in the building codes used in the United States. In order to show the building had adequate fire safety provisions, Rolf Jensen and Associates Inc., a leading U.S. fire protection consulting firm, used the results of the BFRL studies on evacuation by elevators during fires as part of an overall safety performance analysis for the tower. This analysis was sufficient to show local authorities that the building had adequate fire safety provisions. The hotel and casino opened for business on April 30, 1996.

3.13 Welded steel moment frame (WSMF) buildings studied

Many welded steel moment buildings have been built in recent years to take advantage of the ductility of steel when subject to earthquake ground shaking. However, one of the major findings from reconnaissance efforts following the 1994 Northridge earthquake was the discovery of the failure of over 100 welded steel moment frame (WSMF) buildings at welded joints. Similar damage was also observed in the 1995 Kobe earthquake. BFRL is an active participant in the SAC (SEAOC, ATC, and CUREe) effort established after the Northridge earthquake to address critical issues in repair, retrofit and new design of steel frame buildings.

BFRL-sponsored efforts in the past two years were part of a comprehensive national program to address those critical issues. They included the publication of the proceedings of a Workshop on the Seismic Performance of Steel Frame Buildings during the Northridge earthquake; the publication of the results of a detailed survey of those WSMF buildings damaged in the Northridge earthquake; the analysis and characterization of actual failed sections of beam-column connections from buildings damaged in the same earthquake; the detailed investigation and analysis of two steel frame buildings which suffered extensive damage in the same earthquake; the development of computer models for analyzing three WSMF buildings damaged in the same earthquake; and the large-scale testing of retrofitted steel moment connections.

Findings from these studies, as well as those from the completion of the SAC program, will provide the needed solutions to those critical issues listed above

3.14 Wind-loading measurement and estimation procedures

Advances in wind loading measurement and estimation procedures have led to the creation of a vast body of differentiated design technologies that result in safer and more economical designs. The widespread application of those technologies requires the development of complex standard provisions that can be too difficult to use — and may not gain acceptance — for routine design. To overcome such barriers BFRL proposed and completed, with partial support from the American Society of Civil Engineers, the development of an interactive computer version of the ASCE 7-95 provisions for wind loads. The BFRL product led to key improvements of the ASCE Standard provisions through checking for consistency inherent in the programming effort; helped ASCE to establish unequivocally the need for computer-based provisions and to take the first institutional steps toward managing this novel approach to standards development; and following the testing of the software, helped to obtain information on users' practical needs. The BFRL effort is the preliminary stage of a research program into the development of a new generation of computer-based standards that use aerodynamic and climatological data bases to allow the calculation of wind loads targeted for specific cases, rather than for broad ranges of situations covered in current standards by generally uneconomical envelope curves.

Investigation of beam column connections

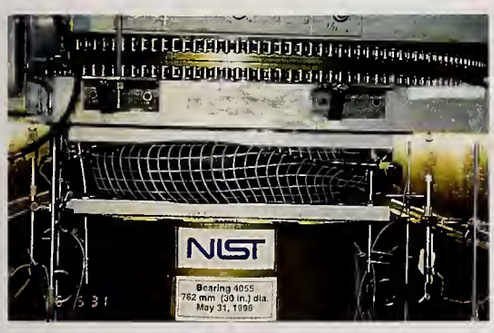
3.15 Methods for estimating extreme wind speeds

New methods for estimating extreme wind speeds, known as peaks over threshold methods, have been applied to hurricane wind speed data used for the development of the ASCE 7-93 Standard wind speed map. The results of the estimates support the hypothesis that the wind extremes are modeled by a distribution with limited upper tail. According to those results the method used in the ASCE 7-93 and 7-95 Standards for obtaining ultimate wind loads from specified basic wind loads is not risk-consistent, that is, it entails structural failure risks estimated to be about one order of magnitude higher in hurricane-prone regions than in regions not exposed to hurricanes.

3.16 Structural control

Seismic isolation has been demonstrated in recent earthquakes as an effective means for reducing the level of response in structures during strong earthquake ground shaking. Testing of the isolation system prior to installation is required by each of the existing building codes that deals with the design of isolated structures. However, standards do not yet exist for conducting these much needed tests, and, therefore, procedures and results are subject to considerable variability. In January 1996, BFRL published guidelines for testing isolation systems. The guidelines address pre-qualification, prototype and quality control testing. The American Society of Civil Engineers (ASCE) is working with BFRL to adopt the proposed guidelines as the basis for developing an American National Standard Institute (ANSI) national consensus standard for testing base isolation systems. ASCE has formed a standard committee and BFRL serves as its technical secretariat.

BFRL has undertaken a series of laboratory tests on seismic base isolation devices using its large-scale testing facility. The purpose of these experiments is to verify the test procedures described in the BFRL test guidelines.

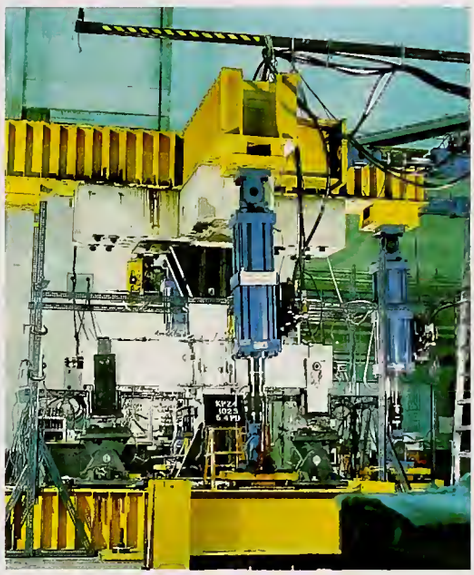


Testing base isolation system

3.17 Seismic performance of precast concrete beam-column connections

The objective of this study is to develop building code provisions for moment-resistant precast concrete beam-column connections based on experimental and analytical work jointly sponsored by BFRL and the private sector and completed at BFRL. Precast concrete beam-column connections offer a good construction practice since precast offers better quality control of its products when manufactured in a controlled environment such as factory. However, precast has not been popularly used by the profession because current practices in precast concrete beam-column connections tend to produce less energy dissipation capability. The work done at BFRL in the past few years focused on the development of better connections technologies that would improve such capability and result in broader use of precast concrete construction. Design guidelines have been developed through the BFRL research. Based on the guidelines, two buildings have been designed and constructed, and three high-rise buildings in seismic regions, ranging from 18 to 45 stories, are currently being designed.

The development of such building code provisions is an important step in the implementation of research results. As of 1996, BFRL-developed design guidelines have been presented to the International Council of Building Officials (ICBO) and the American Concrete Institute (ACI) committees for their consideration for adoption into building codes and standards. Such adoption would allow the use of these connections in the new construction of precast structures in high seismic regions of the country.



Testing seismic performance of concrete beam-column connections

3.18 Design and construction standards for lifeline structures

In response to Public Law 101-614, BFRL, working with the Federal Emergency Management Agency (FEMA), prepared and submitted to Congress *Plan for Developing and Adopting Seismic Design Guidelines and Standards for Lifelines*. The lifelines included in the plan are electric power, gas and liquid fuels, telecommunication/information, transportation, and water and sewer systems. The plan is based on the technical input of experts from the private and public sectors who participated in a workshop held in September 1991 in Denver, Colo. The workshop concluded that design guidelines and standards are needed to reduce the vulnerability of lifelines to earthquakes.

Awards

1995 ASTM William T. Cavanaugh Memorial Award

Dr. Geoffrey Frohnsdorff received the 1995 ASTM William T. Cavanaugh Memorial Award for technical leadership in the initiation and development of national and international standards for construction materials and systems.

1995 ACI

The National Capital Chapter of the American Concrete Institute International (ACI) awarded its Outstanding Accomplishment Award to Dr. James Clifton, Mr. Lawrence Kaetzel and Mr. Kenneth Synder for their efforts to further the use of expert system technology in materials selection and analysis of concrete civil structures.

1996 ASTM Robert J. Painter Award

Dr. Mary McKnight received the ASTM Robert J. Painter Award in recognition of distinguished service, exceptional contributions and achievement and prominent leadership toward advancing the standardization of coatings and lead paint abatement technologies.

1995 ASTM Award of Merit

Dr. Mary McKnight was awarded the 1995 ASTM Award of Merit and honorary title of Fellow for administrative and technical leadership of Committee E06 in the development of standards for the abatement of hazards from leaded paint in buildings.

1996 Catholic University of America Alumni Achievement Award

Dr. David Didion received the Catholic University of America Alumni Achievement Award in Engineering for his research achievements in the field of air conditioning and refrigeration. He pioneered the research of zeotropic refrigerant mixtures and made significant contribution in characterizing alternative, atmospheric-safe refrigerants, He also developed laboratory test methodologies for seasonal efficiency ratings of heating and refrigeration machinery.

1996 DOC Silver Medal

Dr. William Grosshandler was awarded the DOC silver medal for his leadership in research in evaluating alternative fire suppressants for aircraft, providing manufacturers and users of aircraft with the current optimal choice.

1995 NIST Bronze Medal

Dr. Mark A. Kedzierski was awarded the NIST bronze medal for developing an advanced laboratory for measuring the heat transfer coefficient of referigerants.

1996 NIST Bronze Medal

Dr. Jonathan Martin was awarded the NIST bronze medal for the development of methodologies for predicting the service lives of organic coatings and transferring these concepts to the building community.

1996 NIST Bronze Medal

Dr. Andrew Taylor was awarded the NIST bronze medal for the development of standard test procedures for seismic base isolation which will ultimately lead to an ASCE standard.

1995 William P. Slichter Award

The 1995 William P. Slichter Award was awarded to Dr. David A. Didion, Dr. Piotr Domanski and Dr. Mark Kedzierski, for their work in finding alternative refrigerants to the CFCs that have now been banned from production by an international treaty.

1996 William P. Slichter Award

The 1996 William P. Slichter Award was awarded to Mr. Steven Bushby for his work on BACnet, a standard communication protocol for computerized energy management and control systems.

1996 White House "Hammer" Award

The White House presented the Hammer award to Mr. Steven T. Bushby and other participants for a BACnet demonstration project at the Phillip Burton Federal Office Building in San Francisco. The Hammer Award is part of the Clinton Administration's National Performance Review and is given to federal government employees whose work increases the efficiency and effectiveness of government. It is estimated that the BACnet building automation and control system will save the government an estimated $450,000 each year in utility bills.

1996 E.K. Campbell Award

Dr. David Didion was presented with the 1996 E.K. Campbell Award for his pioneering effort in the teaching of current and future technologies to graduate and undergraduate studies.

The Telly Award

The Building and Fire Research Laboratory videotape *BFRL – Your Partner in Building* received a second place Telly Award for production excellence. The video, which was also awarded a Crystal Award, describes BFRL's research programs and facilities and highlights its thrusts in high-performance materials and systems, automation of procedures and facilities and loss reduction.

1996 SRM Service Award

Mr. Robert Zarr recieved the 1996 Standard Reference Material Measurement Services Award for exemplary work in developing and procuring SRM 1453, expanded polyurethane, used in three ASTM standard thermal resistance measurements for fenestration and insulation materials.

1996 BRI Research Award for Foreign Specialist

Dr. William Pitts was the recipient of a 1996 Research Award for Foreign Specialist from the Building Research Institute, Ministry of Construction, Japan. Dr. Pitts spent a month in Japan working with colleagues there and presenting lectures on carbon monoxide formation in enclosure fires.

1995 ARI Meritorious Service Award

This award was presented to Dr. David Didion and Dr. James Hill, for leadership within the federal government on applied research in refrigeration and air conditioning.

1996 LeadTech Government/Industry Person of the Year Award

Dr. Mary McKnight was presented the 1996 Lead Technology Government/Industry Person of the Year Award for outstanding service to the lead industry.

Staff Recognition

NASA payload mission specialist (astronaut)

Dr. Greg Linteris was selected to be a payload mission specialist (astronaut) for NASA to conduct experiments on combustion and material behavior under the microgravity condition of the space shuttle. His mission is scheduled to fly in Spring 1997.

President ASHRAE

On July 1, 1996 Dr. James E. Hill, Chief of the Building Environment Division, became President of the American Society of Heating, Ventilating, and Air-Conditioning Engineers, Inc. ASHRAE is a technical society with 50,000 members in 120 countries around the world. Founded 100 years ago its objective is to advance through research, standards writing, and continuing education the arts and sciences of heating, ventilating, air-conditioning, and refrigeration for the public benefit. Dr. Hill joined ASHRAE in 1972 and was elevated to the grade of Fellow in 1990.

Fellow of the American Concrete Institute

Mr. James Pielert has been elevated to the grade of Fellow of the American Concrete Institute for his work in support of the industry as Manager of the Cement and Concrete Reference Laboratory. Mr. Pielert joined NIST in 1971.

NIST Competence Project

As a result of BFRL's initiative, BFRL and three other NIST laboratories (Physics Laboratory, Mechanical Engineering Laboratory and Information Technology Laboratory) were awarded a competence project on appearance. (A competence project is awarded by the Director of NIST to develop expertise in a broad technical area of future need.) The five-year objective of the project is to develop improved measurement methods and models for predicting the appearance of coated objects. The project is important because the appearance (color, gloss, texture) of an object often influences a customer's judgment of its quality. Moreover, customer expectations for appearance attributes of coatings are continually increasing, as manufacturers demonstrate their ability to provide coatings having new and exciting appearance attributes. To enhance the development and implementation of new coating products, it is essential that the industry have the physical tools necessary to quantify accurately the appearance of a product, and the modeling capability to predict the appearance of a coated object based on the microstructure of the coating. This will be accomplished by taking advantage of recent advances in optical metrology, mathematical modeling and computer rendering to advance significantly measurements and models for appearance of coated objects.

PE licenses (Virginia)

Mr. Ronald Holsinger and Dr. Andrew Taylor have each earned their professional engineering license in civil engineering from the State of Virginia and the State of Washington, respectively.

1995 Technical Focus Speaker for the Federation of Coating Societies for Coatings Technology

Dr. Jonathan Martin received the prestigious Technical Focus Speaker Award at the annual meeting of the Federation of Societies for Coating Technology, a meeting that attracts more than 3,000 international experts in all forms of organic coatings. The subject of his presentation was "Service Life Prediction".

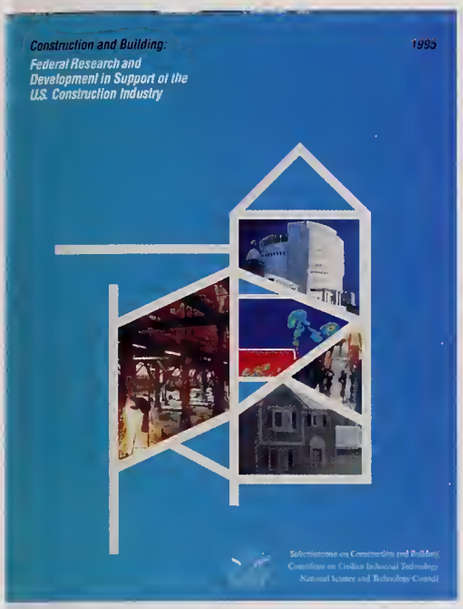
Membership on the Bureau of RILEM

Mr. James Pielert was elected to the Bureau of RILEM at its October 1995 meeting. RILEM, the International Union of Testing and Research Laboratories for Materials and Structures, has over 700 members in some 70 countries. The purpose of RILEM is to collect, analyze and disseminate knowledge on the properties and performance of materials and structures, development of test methods, and application of results in buildings and civil engineering. The Bureau is the management arm of RILEM, responsible for its overall operation.

Gordon Conferences

Dr. Kermit Smyth was invited to present a paper at the 1995 Gordon Conference on Lasers in Combustion, and Dr. Jeffrey Gilman was invited to present a paper at the 1996 Gordon Conference on Thermosetting Resins.

NSTC Subcommittee on Construction and Building



This 1995 publication describes the mission and goals of the subcommittee and activities of the member agencies

CTI's Subcommittee on Construction and Building (C&B) defines priorities for Federal research, development, and deployment related to the industries that produce, operate, and maintain constructed facilities, including buildings and infrastructure

The activities of the National Science and Technology Council (NSTC) Subcommittee on Construction and Building (C&B) have profound effects on the BFRL program. BFRL co-chairs and maintains the secretariat of C&B. NSTC, a cabinet-level group charged with setting federal technology policy, coordinates R&D strategies across a broad cross-section of public and private interests. NSTC has established nine research and development committees, including the Committee on Technological Innovation (CTI), to collaborate with the private sector in developing a comprehensive national technology policy. The purpose of CTI is to enhance the international competitiveness of U.S. industry through federal technology policies and programs. CTI's Subcommittee on Construction and Building defines priorities for federal research, development and deployment related to the industries that produce, operate, and maintain constructed facilities, including buildings and infrastructure. These priorities and related collaborations with industry and government guide the focus of the Laboratory's programs.

Agencies (listed below) participating in C&B include agencies with responsibilities as owners and operators, regulators and researchers.

- Department of Agriculture (Forest Products Laboratory)
- Department of Commerce, Co-chair (NIST)
- Department of Defense
- Department of Energy, Co-chair
- Department of Health and Human Services (National Institute of Occupational Safety and Health)
- Department of Housing and Urban Development
- Department of Interior (United States Geological Survey)
- Department of Labor (Occupational Safety and Health Administration)
- Department of Transportation (Federal Highway Administration)
- Department of Veterans Affairs
- Environmental Protection Agency
- Federal Emergency Management Administration
- General Services Administration
- National Science Foundation

The mission of C&B is to enhance the competitiveness of U.S. industry, public and worker safety and environmental quality through research and development, in cooperation with U.S. industry, labor and academia improve the life-cycle performance and economy of constructed facilities. C&B addresses Administration goals to:

- forge partnerships with industry to strengthen America's industrial competitiveness and create jobs; and

- make environmental protection, safety and energy efficiency fully consistent with other business objectives.

During FY 95 C&B studied research priorities expressed by the construction industry in industry forums and in proposals for the Advanced Technology Program of the Department of Commerce. Two priority thrusts, better constructed facilities and health and safety of the construction workforce, were defined for focus of research, development and deployment (RD&D) in the construction and building area. The C&B program plans to cooperate with industry to make technologies and practices capable of achieving the following seven goals available for use in the construction industry by 2003.

Better Constructed Facilities

- ✔ 50% reduction in delivery time
- ✔ 50% reduction in operation, maintenance and energy costs
- ✔ 30% increase in productivity and comfort
- ✔ 50% fewer occupant -related illnesses and injuries
- ✔ 50% less waste and pollution
- ✔ 50% more durability and flexibility

Health and Safety of Construction Workforce

- ✔ 50% reduction in construction work illnesses and injuries

Excavation for NIST's new Advanced Chemical Sciences Laboratory

The baseline for measuring progress against the goals will be today's business practices. Long delivery time, waste and pollution, and construction work illness and injury contribute substantially to unnecessary increases in the cost of construction. Therefore, achievement of these goals will reduce construction cost and make housing more affordable through reduction in first cost and life-cycle cost. The C&B program and goals were reviewed with a focus group of industry leaders convened by the Civil Engineering Research Foundation. These leaders strongly endorsed the goals, which became known as the National Construction Goals.

During FY 96, C&B worked with industry groups convened by the National Association of Homebuilders (residential sector), the Construction Industry Institute (industrial sector), the National Institute of Building Sciences (commercial/institutional sector) and the American Public Works Association (public works sector) to stimulate the development of industry plans. The development of these plans revealed major differences among the sectors' priorities and needs. Therefore, industry will focus on sector goals, and work with appropriate federal agencies on collaborative efforts to address sector goals.

C&B also held a workshop to strengthen mechanisms for collaborating with the private sector. The report of that workshop notes successful collaborative efforts in recent years, describes federal laboratory capabilities and facilities, and identifies current areas of research suitable for collaboration. C&B supported a study to develop baseline measures of current practice and measures of progress with respect to each of the national construction goals, and completed a survey of Federal R&D for construction. C&B has two of its recent reports on the world wide web, and plans to make all future reports similarly available.

Four agencies of C&B, (NIST, HUD, Corps of Engineers, and DOE) supported the Partnership for Building Innovation which organized a workshop in June, 1996, in Washington D.C. to plan the strategy for stimulating the acceptance of innovations in building practice. An agreement was reached between the Civil Engineering Research Foundation (CERF) and the National Evaluation Service to develop an enhanced evaluation process that uses experts to identify performance criteria, and expert evaluations to evaluate products and processes against those criteria.

NSTC Subcommittee on Construction and Building

In August 1995 the CONMAT Council was formally established to implement the high-performance CONstruction MATerials and systems program designed to create a new generation of constructed facilities. The Council consists of 12 different material groups (aluminum, coatings, concrete, fiber-reinforced composites, geo-synthetics, masonry, plastics, roofing materials, smart materials, stainless materials, steel and wood) as well as liaison members from public and private agencies, with CERF acting as Secretariat. These groups have joined forces in a $2 billion effort to plan and implement a national program of research, development and deployment. The CONMAT plan, *Materials for Tomorrow's Infrastructure : A Ten Year Plan for Deploying High-Performance Construction Materials and Systems,* was published in FY 95. The National Construction Goals provide a strong focus for the CONMAT program. High-performance construction materials and systems will play a key role in reaching the goals. For example, high-performance concrete that is more easily placed will result in reduced inspection and maintenance costs associated with repair. Similar examples exist for most other materials.

NCSBCS is bringing together federal, state, and local government regulators and construction industry representatives to streamline the regulatory process.

A contract has been signed with the National Conference of States on Building Codes and Standards (NCSBCS) to start a project on "Streamlining and Reforming the Nation's Building Regulatory System to Facilitate Public Safety, Economic Development, and the Use of Innovative Technologies," which addresses the goal for reduction in delivery time. A letter from Dr. Good, Under Secretary for Technology, to most agencies involved in construction and building R&D, regulation and federal construction has developed positive response from a number of agencies. The project was announced to interested organizations at the NCSBCS annual convention in September. The project will collect viable model rules, regulations, processes, procedures or legislation for effective and efficient building, fire safety and environmental codes and standards adoption and enforcement, permitting, administration and processing, comprehensive planning, infrastructure, zoning and land use, building design and construction, building product approvals, and education and training. Subsequently the project partners will develop model procedures and implementing legislation and promote the adoption and use of such streamlined processes and procedures by all levels of government.

The primary efforts of the C&B Subcommittee for 1997 will be working with industry to achieve construction goals, streamlining regulation, focussing and coordinating federal R&D on collaborations with industry and supporting other multi-agency initiatives associated with construction and building.

An agreement was reached between CERF and the National Evaluation Service to develop an enhanced evaluation process

Outreach

The Laboratory has made a concerted effort to improve communication with the building and fire communities through printed and electronic media. *Collaborating With Our Customers,* a full-color brochure, describes the organization, facilities, and programs of the Building and Fire Research Laboratory of interest to: owners, designers and constructors; producers and suppliers; standards and codes developers; and fire safety officials. It has been widely distributed to industry, organizations, academia and government agencies. An 18-minute video, *BFRL – Your Partner in Building* has been widely distributed. To provide more detailed information on our technical programs and products, three special publications have been released, *Project Summaries, Publications,* and *Impacts.* These documents have been produced only annually, so BFRL has added a full-color *Research Update,* which is mailed to about 5,000 recipients.

For more than two years BFRL has had a site on the World Wide Web and is constantly updating its home page and redesigning its organization to include more news items such as those appearing in *Research Update* and provide easier access to items of interest to users. In addition to the Web site, BFRL has initiated an intranet on its local area network for use by BFRL staff only. This intranet will improve communications within the laboratory and make more information easily available to staff in an electronic format.

Collaboration with Industry

Much of the C&B effort noted above has been in collaboration with industry. The NIST Building and Fire Research Laboratory's "strategy for success" is to build on the ties that have been developed to identify research needs, focus our program on meeting those needs and provide products that will assist the sectors of the construction and building industry (residential, commercial, institutional, industrial and public works) to meet their expressed goals. To take advantage of the formation of sector groups working with C&B, namely the Civil Engineering Research Foundation, the National Association of Homebuilders, the National Institute of Building Sciences, the Construction Industry Institute, and the American Public Works Association, BFRL has identified a senior staff person to work with each group, attend their meetings, and find out their research needs so that BFRL could shape its building and fire research program to better meet the needs of industry.

Industry Consortia

BFRL works with industry consortia in a number of areas including the demonstration of a standard communication protocol for building automation and control systems (BACnet), an application protocol for the process plant industries (PlantSTEP), the development of plans for high performance construction materials (CONMAT), the prediction of the service life of paint, the demonstration and validation of methods to predict and relate the photodegradation response of coating systems exposed to UV radiation, the development of a methodology for evaluating seams of rubber roofing membranes, the development of guidelines for intentional burning of fuel spills on land and water, and evaluation of combined installations of sprinklers, draft curtains and heat and smoke vents for fire protection in industrial buildings.

BACnet

BFRL has entered into a cooperative research and development agreement with 17 partners to develop interoperable building control equipment that communicates using the BACnet protocol. Fifteen of the consortium members are manufacturers of building control equipment, one is a software development company, and one is a university. The objective of the consortium is to assist the member companies in developing products that conform to the BACnet standard and to develop conformance testing tools and procedures that can be used to establish an industry-run certification program. BACnet building control products will enable building owners to buy control systems on a competitive basis. It will also provide a way to interconnect traditionally stand-alone building control systems such as HVAC, fire, lighting and security. This will enable buildings to operate more efficiently while improving occupant comfort and safety. Five of the consortium member companies now have commercial BACnet products on the market and BACnet systems have been installed in approximately 350 buildings world wide. BFRL's contribution to the consortium has been the development of test methods and software testing tools and provision of facilities for member companies to bring their prototype products together for testing.

BACnet systems have been installed in approximately 350 buildings world wide

PlantSTEP

As a result of the BFRL collaboration with the PlantSTEP consortium, the first STEP application protocol for the process plant industries, ISO 10303-227, was submitted to ISO TC184/SC4 for review and ballot as an ISO committee draft standard. The process plant industries include the chemical, pharmaceutical and power-generation industries, engineering and construction industries, and the suppliers and fabricators of components and equipment for process plants. NIST engineers are working with the process plant industries and the vendors of information technology for these industries to develop, test and demonstrate information exchange standards based on ISO 10303, commonly referred to as STEP, Standard for the Exchange of Product Model Data. ISO 10303-227, Plant Spatial Configuration, supports the exchange of the spatial configuration of plant systems with a central emphasis on piping systems. This committee draft standard supports the information required to construct piping systems, including the shape, material and arrangement of components, and supports the physical description of other plant systems, e.g., heating, ventilation and air conditioning systems.

CONMAT

BFRL, in collaboration with the Materials Science and Engineering Laboratory, established a $2.5 million per year program in support of CONMAT, a national program developed by Civil Engineering Research Foundation, working with 12 major associations of the construction materials industry, to "develop the high-performance construction materials and systems necessary for America's economic well-being and international competitiveness in the 21st century." The program involves four BFRL divisions plus the Office of Applied Economics and includes research on high-performance concrete, steel, polymer-matrix composites, coating materials, and roofing systems.

Coatings Service Life Consortium

Seven members of the paint industry have joined with BFRL to form the Coatings Service Life Prediction Consortium. The goal of the consortium is to find a better way to predict the service life of paint to help the paint industry get better products to market faster. The consortium's main project will be to develop a test method that will quickly and reliably predict the service life of painted products exposed to the prime weathering factors: sunlight, temperature and wetness. BFRL will also work with the members to tailor a weathering test program for each member's needs. In addition, BFRL will develop a menu-driven, user-friendly system to help weathering laboratories design experiments, test assumptions and fit models.

Rubber Roofing Membranes

Three rubber membrane manufacturers, two adhesive manufacturers and two trade associations have joined with BFRL to form the Consortium for Developing a Methodology for Evaluating Seams of Rubber Roofing Membranes. EPDM rubber accounts for about 30 percent of the roof membranes installed on commercial and industrial buildings. The goal of the consortium is to recommend a test protocol and criteria for evaluating the long-term creep performance of tape-bonded seams in EPDM membranes. The use of tape-bonded seams is a rather recent innovation in the EPDM roofing industry, and its use is expected to increase in the future in response to needs for reliable, environmentally friendly methods for forming seams in EPDM membranes.

Oil Spill Clean-Up

Several regions of the United States, Canada and Europe are presently evaluating the feasibility of using burning as a remediation tool for large oil spills. In particular, the Alaska Regional Response Team (ARRT) has been working over the past decade to develop procedures and guidelines to facilitate the decision process regarding international in situ burning of crude oil spills. As part of their effort to assess the dispersion of smoke plumes from in situ burning on nearby areas, the ARRT and the Alaska Department of Environmental Conservation (ADEC) established a Cooperative Research and Development Agreement with the NIST in 1993. Laboratory-scale and large-scale experiments have been conducted to determine the heat release rate and smoke yield from two types of Alaskan crude oils, North Slope and Cook Inlet, as well as several other fuels. These experiments have been used to determine the input parameters for the ALOFT (A Large Outdoor Fire Plume Trajectory) model. This numerical model predicts the concentration of combustion products from large oil fires several kilometers to several tens of kilometers downwind over complex terrain. Using Digital Elevation Maps provided by the U.S. Geological Survey, site-specific simulations of smoke plumes have been performed to establish guidelines governing the extent of ground-level particulate concentrations in excess of state and national ambient air quality standards. Cooperation in this effort has been provided by Alaska Clean Seas, an oil spill cooperative funded by the major oil companies, and by EMCON Alaska, Inc., an environmental consulting firm. (EMCON is presently funding NIST to develop the complex terrain plume model.)

Sprinklers/Draft Curtains/Vents

The National Fire Protection Research Foundation (NFPRF) has undertaken a project to evaluate the interaction of sprinklers with draft curtains and smoke/heat vents. The goal of the project is to provide a new technical finding that could aid in settling the long-standing debate as to the conditions under which vents and draft curtains are beneficial, and under which they are detrimental, to the performance of a sprinkler system in large enclosures. To reach the goal, full-scale commodity fires are being planned by BFRL engineers David Stroup and Kevin McGrattan for a space that will mimic as much as possible large storage and manufacturing facilities. Accompanying the experimental work will be an effort to simulate the proposed experiments with a field model presently under development by Kevin McGratten. The project is being funded by a consortium of ten companies in the United States and Europe. The large-scale testing will take place in 1997, accompanied by smaller scale material testing at BFRL under the direction of Anthony Hamins.

Cooperative R&D Agreements

In addition to agreements signed with consortia, NIST has cooperative research and development agreements (CRADAs) with one or more industrial partners. Current CRADA's partners include:

MSI Inc. (formerly Biosym, Inc.).

Under a CRADA between NIST and this commercial molecular modeling company the two organizations announced a new computer code to be released in 1997. This computer code will include NIST algorithm, MD_REACT, which calculates the behavior of polymer chains during thermal degradation. The interface between the Biosym and NIST soft-ware was developed by Marc Nyden, a BFRL scientist.

Air-Conditioning and Refrigeration Institute

A CRADA to study the performance of a finned-tube evaporator operating with R-407C, an ozone-safe zeotropic refrigerant mixture has been established between NIST and the Air-Conditioning and Refrigeration Institute, an association of manufacturers of heating, ventilating, air-conditioning and refrigeration products. The title of the CRADA is "Impact of Air-Side Maldistribution on Performance of Finned-Tube Evaporator with R-22 and Zeotropic Mixture R-407C." The effect of non-uniform air distribution on the heat exchanger's capacity is the particular interest of this project. The study will determine whether the capacity penalty caused by non-uniform air distribution at the heat exchanger's inlet is similar to that experienced with the R-22 evaporator and will indicate the circuitry arrangements most appropriate for R-407C. This information will enable the evaporator designer to generate coil designs

that will be less affected by air maldistribution. As the technical contribution to this partnership with ARI, NIST has developed a detailed evaporator model applicable to zeotropic mixturesand maldistributed air and performed simulations for a variety of air maldistributions andcircuitry designs.

General Motors

NIST has joined forces with General Motors in a two-year project to improve motor vehicle fire safety. Under terms of the recently signed cooperative research and development agreement, researchers from the Building and Fire Research Laboratory and GM's Research and Development Center will evaluate the fire safety aspects of vehicle crash and fire tests, identify potential mechanisms by which fires could start and then create laboratory models of these mechanisms. The data derived will enable researchers to characterize fire properties of potential combustibles in vehicles, determine fire growth paths and time lines, and evaluate fire hazards to vehicle occupants. GM and NIST will then use this knowledge to study both passive protection measures (e.g., less flammable materials in critical locations and improved fire barriers) and active fire suppression technologies.

Electric Power Research Institute

NIST has a CRADA with the Electric Power Research Institute (EPRI). EPRI is funded by annual membership dues from some 700 member utilities, and its work covers a wide range of technologies related to the generation, delivery and use of electricity, with special attention paid to cost-effectiveness and environmental concerns. The joint effort between EPRI and NIST will produce detailed information on the indoor air quality and energy impacts of residential ventilation systems. This information will enable informed decisions regarding ventilation system selection and design as a function of building type, indoor pollutant emissions and climate. As of November 1996, EPRI and NIST have agreed on the house, system and pollutant parameters that will be examined in the project and have started the computer simulations that will be the major component of the effort. NIST's contribution to this partnership involves performing the computer simulations and analyzing the output.

Another CRADA with EPRI allows NIST to access to the strong motion records that EPRI was able to collect from the Lotung strong motion array in Taiwan. Analysis of these data will enhance our understanding in the non-linear soil behaviors, which is critical to the analysis of the performance of buildings and lifelines subject to strong ground shaking.

This information will enable informed decisions regarding ventilation system selection and design as a function of building type, indoor pollutant emissions and climate

Process Data Exchange Institute

In September 1995, BFRL and the Chemical Science and Technology Laboratory entered into a CRADA with the Process Data Exchange Institute (pdXi) of the American Institute of Chemical Engineers. The mission of pdXi is to develop and maintain open approaches to electronically exchange and manage process data. The objective of this CRADA is to develop, test, demonstrate and standardize STEP application protocols needed for exchanging and sharing conceptual process design and process engineering information during the design, construction, maintenance and operations of process plants, e.g., chemical, pharmaceutical and power-generation plants. The current members of pdXi include: ABB Lummus, Air Products, Amoco Chemical, Aspen Technology, Bechtel, B-JAC, Brown & Root, Chevron, Eastman Chemical, E.I. DuPont & Co., Exxon, HTFS, HTRI, Hyprotech, M. W. Kellogg, Mobil R&D, Rohm & Haas, Simulation Sciences, Snamprogetti, Union Carbide and UOP. The delivery and implementation of the STEP application protocols for process engineering will: 1) enable timely and reliable information sharing during the design, construction, maintenance and operation of process plants, 2) reduce information transfer costs and errors, 3) enable optimization of work processes and project partnerships, 4) expand the use of electronic commerce, and 5) expand the capabilities of the U.S. process, engineering and equipment manufacturing industry to leverage information technology for competitive advantages. NIST is providing technical support for the development of the application protocols, coordinating collaborations with international programs and ISO, and providing a neutral laboratory for testing draft application protocols, assessing implementations, and demonstrating results. NIST and pdXi completed the requirements specification for the Process Engineering Application Protocol (AP 231) and distributed the requirements specification for industry review and comment in September 1996 (NISTIR 5909). NIST and pdXi developed an initial set of test problems and usage scenarios for validating the draft application protocol and for assessing implementations of the application protocol. The CRADA is scheduled to end in September 1997.

Codes and Standards

Building codes and standards play an important role in the delivery mechanism for much of the research of the BFRL. BFRL staff participate in many national and international standards committees, including those of the American Concrete Institute; American Society of Civil Engineers; American Society of Heating, Refrigeration and Air Conditioning Engineers; American Institute of Steel Construction; ASTM; the National Fire Protection Association; and the International Organization for Standardization. The broadest range of participation is in ASTM where involvement includes Committee C009, Concrete and Concrete Aggregates; Committee D001, Paint and Related Coating Materials; Committee D004, Road and Paving Materials; Committee D008, Roofing, Waterproofing and Bituminous Materials; Committee E05, Fire Standards; and Committee E06, Performance of Buildings. Through its national standards activities and its participation in the International Advisory Committee of the International Codes Council, BFRL is supporting the council's development of a single national model building code.

Japan

UJNR Panel on Fire Research and Safety

The objective of the U.S.-Japan Natural Resources Program (UJNR) is to exchange information on research results and exchange scientists and engineers in the area of natural resources for the benefit of both countries. UJNR is composed of 16 panels, each responsible for specific technical subjects.

The 13th Joint Meeting of the U.S.-Japan Panel on Fire Research and Safety took place at NIST in March 1996. The objectives of the panel, which was established in 1975, are to: encourage, develop and implement the exchange of information and data in fire and smoke physics, toxicity, chemistry and risk and hazard evaluation; promote cooperative research in areas of fire safety and combustion toxicity; encourage innovations in development of risk assessment methods, fire test methods and design standards; establish a multinational consensus of computer-based fire modeling; develop performance fire codes; and develop new fire protection and prevention technology appropriate to modern products and design. The Japanese sent a delegation of 25 scientists for this year's meeting and the U.S. had 48 participants including many NIST staff. A total of 67 technical papers were presented in sessions devoted to design/risk/performance standards, burning of real objects, experimental refinement and validation of fire models, suppression, materials and testing, and fires after earthquakes. As part of the panel meeting, symposia were held to honor two mainstays of fire research: a session in honor of Prof. Edward Zukoski on the occasion of his retirement from the California Institute of technology and one was held in memory of Prof. Kunio Kawagoe of Tokyo Science University.

Collaborative research in U.S. and Japanese laboratories has enabled staff from each country to use facilities not existent at home. The research has advanced the state of fire science and technology in such areas as fire smoke toxicity, fire detection, fire suppression, micro gravity combustion, thermal degradation of polymers, intumescent polymer burning, wall fire modeling, smoke yields from pool fires, smoke flow in buildings, building fire modeling, large fires and rate-of-heat release measurement. These joint efforts have built the knowledge base on essential fire phenomena to support the development and validation of models to predict fire hazard and risk.

UJNR Panel on Wind and Seismic Effects

The 28th Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held at NIST in May 1996.

NIST provides the U.S.-side chair and secretariat. The Public Works Research Institute (PWRI), Japan, provides the Japan-side chair and secretariat. Forty-six papers were written, 21 by U.S. members and 25 by Japanese members. Thirty-four papers were presented orally; 16 by the U.S.-side and 18 by the Japan-side. The papers were organized into five themes: Wind Engineering; Earthquake Engineering; Storm Surge and Tsunamis; Summary of Joint Cooperative Research Programs; and Report of Task Committee Workshops conducted during the past year. Also, eight papers were presented at two mini-symposia during the technical site visit segment of the Joint Panel Meeting, four from each side. The papers were presented at the University of Minnesota, Minneapolis, and at the Oregon Department of Geology and Mineral Industries, Portland. The Japan-side papers are included in these proceedings in the section, *Japan-side Papers Presented at Mini-Symposia.* These joint efforts have led to substantial improvements in U.S. and Japanese wind and earthquake safety knowledge and priorities.

U.S.-Japan Panel on Wind and Seismic Effects was held at NIST in May 1996

Panel on Innovation in the Japanese Construction Industry

Richard Gann, Chief of the Fire Science Division, chaired the U.S. Panel on Innovation in the Japanese Construction Industry, which prepared the 1996 report, *Innovation in the Japanese Construction Industry: A 1995 Appraisal.*

This panel found the Japanese construction industry to be solid and progressive. The large firms have superb laboratories, with nearly 10 times the U.S. R&D expenditures. The Japanese industry still surpasses the U.S. industry in most construction technologies. The report documents the status of these technologies and the motivations for the continued R&D investment. At the time the report was prepared, the Japanese domestic recession and the strong yen were taking a strong toll, and the panel saw only refinements of technologies introduced earlier and applications of lessons learned. However, should the yen exchange rate rise, Japan is well-poised to increase its successes in the international competition. The U.S. industry would be helped by improved public/private sector R&D efforts.

The Japanese industry still surpasses the U.S. industry in most construction technologies

Korea

In September 1995, an Implementing Agreement was signed between NIST and the Korean Institute of Energy Research of the Republic of Korea. The agreement is for a period of five years and its purpose is to exchange scientific and technological knowledge and to encourage the joint research in the field of energy technology. The first two years of this agreement will involve conducting joint research and the possible exchange of personnel to develop methods for the automated real-time performance optimization, fault detection and diagnosis of thermal systems, especially HVAC processes to improve energy efficiency, increase safety and reliability and reduce operating cost.

Saudi Arabia

NIST has developed a program to assist developing nations in the use of U.S. building codes and standards. This work is being conducted in cooperation with the National Conference of States on Building Codes and Standards. The first country identified is Saudi Arabia which has requested NIST to assist in the development of a building code and standards program for the country as a means to improve opportunities for economic development and safeguard the health and safety of its people.

International Organization for Standardization

Through the International Organization for Standardization, NIST engineers and scientists have participated in the development of technical reports, guides and international standards in five areas, namely, coatings (TC 35/SC9), functional/ user requirements (TC59/SC3), fire safety engineering (TC92/SC4), plant industry standard technical exchange protocols (TC184/SC4), and building control system design (TC205/WG3). In addition, by participating in ISO Technical Advisory Groups on building and civil engineering construction standards, NIST engineers can follow the progress of technical committees dealing with the basis for the design of structures, reinforced and prestressed concrete, timber structures, steel and aluminum structures, masonary, thermal insulation, environmental design and environmental management.

TC35, Paints and Varnishes, established in 1947, writes standards for the coatings industry, including those addressing methods of testing and specifications for coating components and for ready-made coatings in liquid or powder form. SC9 is the subcommittee on general test methods for paints and varnishes. It has 10 active working groups addressing physical, mechanical and optical properties of coating films, fire testing, leaching rates from antifouling coatings and environmental and performance testing. This ISO subcom mittee provides an avenue for NIST's program on lead abatement and the Coatings Service Life Prediction Consortium program on the prediction of the service life of paint to impact international markets. NIST hosted the 1996 meeting of SC9.

Geoffrey Frohnsdorff chairs TC59/SC3/W69, addressing the design life of buildings. The committee is producing a series of documents dealing with the planning of, and maintenance management for, the service life of buildings.The design life of buildings is becoming progressively more important internationally not only because of the cost of building replacement but also because of the environmental impact of building demolition waste and the need for raw materials. BFRL's program on high performance materials and systems will have a strong influence on the direction of the ISO activity. BFRL engineers are also helping to develop performance standards for one and two family dwellings. These performance standards are intended to assist the U.S. housing industry in removing barriers to U.S. housing products and will provide the basis for increased global trade in housing products, components, systems and know-how.

TC 92/SC4 is developing eight guides and technical reports including a framework for fire safety calculations, the assessment and verification of fire models, the generation of fire effluents, fire spread, detection and extinguishment and life safety. BFRL work on fire models and their verification has had a major influence on the technical content of these international reports expected to be completed in draft early in 1997.

TC184/SC4 has initiated projects to develop STEP Application Protocols for information exchange in a number of industrial sectors. BFRL engineers are helping to plan and coordinate AP projects in WG3/T12, which covers architecture, engineering and construction, and are making techinical contributions to specific projects that address the needs of the process plant industries, notably ISO 10303-221 *Functional Data and their Schematic Representation for Process Plants.* ISO 10303-227 *Plant Spatial Configuration,* ISO 10303-230 *Building Structural Frame: Steelwork,* and ISO 10303-231 *Process Engineering Data.* The AP227 and AP231 projects were described in an earlier section.

BFRL engineer Kent Reed is working collaboratively with the American Institute of Steel Construction to review the STEP AP230 project on steelwork and ensure U.S. requirements are met. This application protocol is intended to support computer applications providing analysis, member design, connection design and detailing functions to designers and constructors of structures in buildings and plants. Reed is working collaboratively with researchers at Carnegie Mellon University to understand the requirements for capturing information during early building design and with a researcher at the University of Maryland to understand the requirements for supporting constructability analysis programs. BFRL engineer Mark Palmer is working within the United States and in the ISO arena to ensure technical harmonization of the STEP AP221, AP227 and AP231 projects.

TC 205/WG 3 Building Control System Design is working to develop a multipart international standard for various aspects of building control system design and practice. The parts of the standard are: overview and definitions, control system functionality, communication protocols, control system specifications, and project management process. Various existing national and European standards, including ANSI/ASHRAE 135 BACnet, are being considered for adoption as a draft standard for the various parts of this effort. The convenor for this working group is BFRL staff member Steve Bushby.

International Council for Building Research Studies and Documentation (CIB)

Jack Snell serves on the board of the International Council for Building Research Studies and Documentation (CIB) which is the principal international forum for communication among building researchers - whether in government, academia or industry. CIB is in a period of transition. In the past, it served mostly European institutes for building research and testing. More recently it has been increasingly a venue for academia building researchers. Most recently, a number of trends have come to bear on CIB, including diminishing governmental roles and increasing industry involvement in building research; internationalization and global markets; a growing emphasis on non-technical topics and multidisciplinary approaches (from a product/testing orientation to greater attention to system and problem solving); and, of course, advances in technology, most notably computer and information technologies. On top of this, CIB now has a new Secretary General, Wim Bakens, who is eager to see CIB respond to new opportunities by exploiting information technology, providing new products and services to industry, seeing CIB take a proactive role in prestandardization activities, aggressively developing its membership and developing purposeful relationships with external organizations.

BFRL engineer Richard Bukowski represents building and fire interests in CIB Commission W14 on Fire Safety. He chairs a working group on a multinational effort to examine the predictive capability of fire models. Also, James Gross, Assistant Director of BFRL, is actively involved in the development of performance standards for buildings.

In cooperation with colleagues in the private sector, BFRL engineer Steven Bushby presented the progress made on the development of communication protocols for building automation systems at the 13th International CIB World Congress.

RILEM

James Pielert, who heads the NIST Concrete Materials Testing Laboratory, is the U.S. delegate to RILEM, the International Union of Testing and Research Laboratories for Materials and Structures. BFRL is recognized for playing a major role in the management of RILEM and playing a major role in several of its technical committees. Construction technology being developed within those technical committees has direct application to the research programs of the Building and Fire Research Laboratory and in the preparation of standards by ASTM and other organizations. Particularly significant to BFRL are the committees on the interfacial transition zone in concrete, modeling, transport properties of concrete, freeze thaw and the de-icing resistance of concrete, the role of admixtures in high performance concrete, the development of a service life prediction methodology for construction materials and roofing materials and systems.

FORUM for International Cooperation on Fire Research

In August 1996, Jack Snell, who directs the BFRL fire research program, was joined by the heads of 14 other fire research laboratories from 12 countries at a meeting of the FORUM for International Cooperation on Fire Research at Trondheim, Norway. BFRL acts as secretariat to the Multi-lab FORUM. Among the specific problems that the FORUM agreed to address are the supply of qualified fire researchers, the coordination of fire incident data, fire tools not arriving in practice, well structured model verification tests, global fire research needs and strategy, funding for fundamental fire research, guidelines for model selection, methods of fire investigation, and research on specific topology of buildings.

American Concrete Institute Advisory Committee

James Gross is a member of the American Concrete Institute Advisory Committee on International Standards which has recently received the Secretariat responsibility of the Committee on Concrete, ISO TC71. Plans are under way to develop performance standards for concrete design of construction.

Major Conferences, Seminars and Workshops

CERF International Symposium: Engineering and Construction for Sustainable Development in the 21st Century

BFRL was a principal co-sponsor and planning director of CERF's International Symposium on Construction and Engineering for Sustainable Development in the 21st Century, February 1996. More than 500 leaders worldwide attended this four-day symposium to develop a detailed global research agenda that focused on the needs of the design and construction communities. Thirty-eight research prospectuses were developed under six themes by the symposium participants that formed the basis for a research agenda. The six themes included:

- learning, education, and training;
- information systems/technology transfer;
- performance specifications/global standards;
- modeling and measurement systems;
- demonstrations and performance testing; and
- integrated delivery systems.

The agenda addressed how to enhance and accelerate the process for moving design and construction technologies into practice. Work was done through five thrusts:

- management and business practices;
- design technologies and practices;
- construction and equipment practices;
- materials and systems; and
- public and government policy.

The next steps involve assembling teams of participating international organizations into consortia to bring the themes into realization.

International Conference on Fire Research and Engineering

The BFRL 1995 annual fire conference was held in Orlando, Fla., and jointly sponsored by BFRL and the Society of Fire Protection Engineers. The conference focussed on advances in fire research and engineering applications and brought together leaders in the field from around the world. Ninety-three papers were presented, together with 18 posters and a special one-half day panel "Defining Fire and Smoke Spread Dynamics in the Dupont Plaza Hotel Fire of December 31, 1986." Session topics included: compartment fires, large fires, suppression, water mist, fire dynamics, wall fires, calorimetry, performance based fire codes, egress/human factors, decision-risk, materials, smoke, model development, model verification, model applications, special hazards, smoke control and fire resistance.

Annual Fire Conference 1996

The 1996 annual fire conference was held in Gaithersburg, Md., and focussed on fire research performed within federal laboratories or sponsored by federal agencies, as well as work from laboratories around the world. Seventy-six papers were presented on the phenomenology of fire. Session topics included: fire extinguishment, the chemistry and physics of material and product combustion, flame spread, flame structure, soot, pool fires, fire-induced flows, fire plumes, combustion product generation and measurement, and fire detection.

Construction Technology Extension Program Workshop

In March 1996 a planning workshop was held in Gaithersburg, Md., to explore the concept of a construction technology extension program styled on the NIST Manufacturing Extension Partnership. The workshop was attended by approximately 45 representatives from industry trade and professional associations, government agencies, labor organizations, academia and small construction firms. The workshop participants identified the most important services that should be provided, including assistance with information technologies; workforce training and education; standards, codes, conformance assessment and product approval; assistance with technical and business practices; and clearinghouse functions. Alternative delivery mechanisms, adding construction expertise to MEP centers and a separate extension network for construction, were discussed extensively. Recognizing that ease and speed of service accessibility by small firms is critical, some combination of the two delivery mechanisms may emerge as the most effective.

CIKS Workshop

A workshop, sponsored by ASTM, CERF and BFRL, was held June 13 and 14, 1996, to discuss a National Partnership on a Computer-Integrated Knowledge Systems (CIKS) Network for High-Performance Construction Materials and Systems. Approximately 70 representatives from construction industry organizations representing private industry; federal, state and local government; and academia attended the workshop. The purpose of the workshop was to provide a forum for discussing a partnership which is designed to stimulate the accelerated and widespread dissemination of knowledge on high-performance construction materials through the development of a CIKS network. The functional goals that are proposed for CIKS which were discussed at the meeting include: 1) providing universal electronic access to distributed material data, information and knowledge; 2) the development of application

systems for use in material design, facility design, construction, operation, maintenance, repair and disposal; 3) the establishment of a test bed for industry, government and university partners to build and evaluate prototype systems and enabling information technologies; and 4) the potential for commercial-scale systems that are developed, deployed and maintained by industry. Pilot projects were identified, discussed and proposed by the seven working groups that met. Several are currently being developed by the CIKS Material Working Groups. A NIST report documenting the workshop findings, results and proposals has been developed and will be published in early 1997.

Fire/Lifeline Interface Workshop

Working with the U.S. fire protection and lifeline engineering communities, BFRL conducted a Fire/Lifeline Interface workshop in late January 1995 to discuss important issues identified as a result of recent damaging earthquakes. The workshop proceedings, published in September 1995, summarize the workshop findings and recommend research priorities. Based on these recommendations, BFRL has provided over 20 grants to the private sector and to universities.

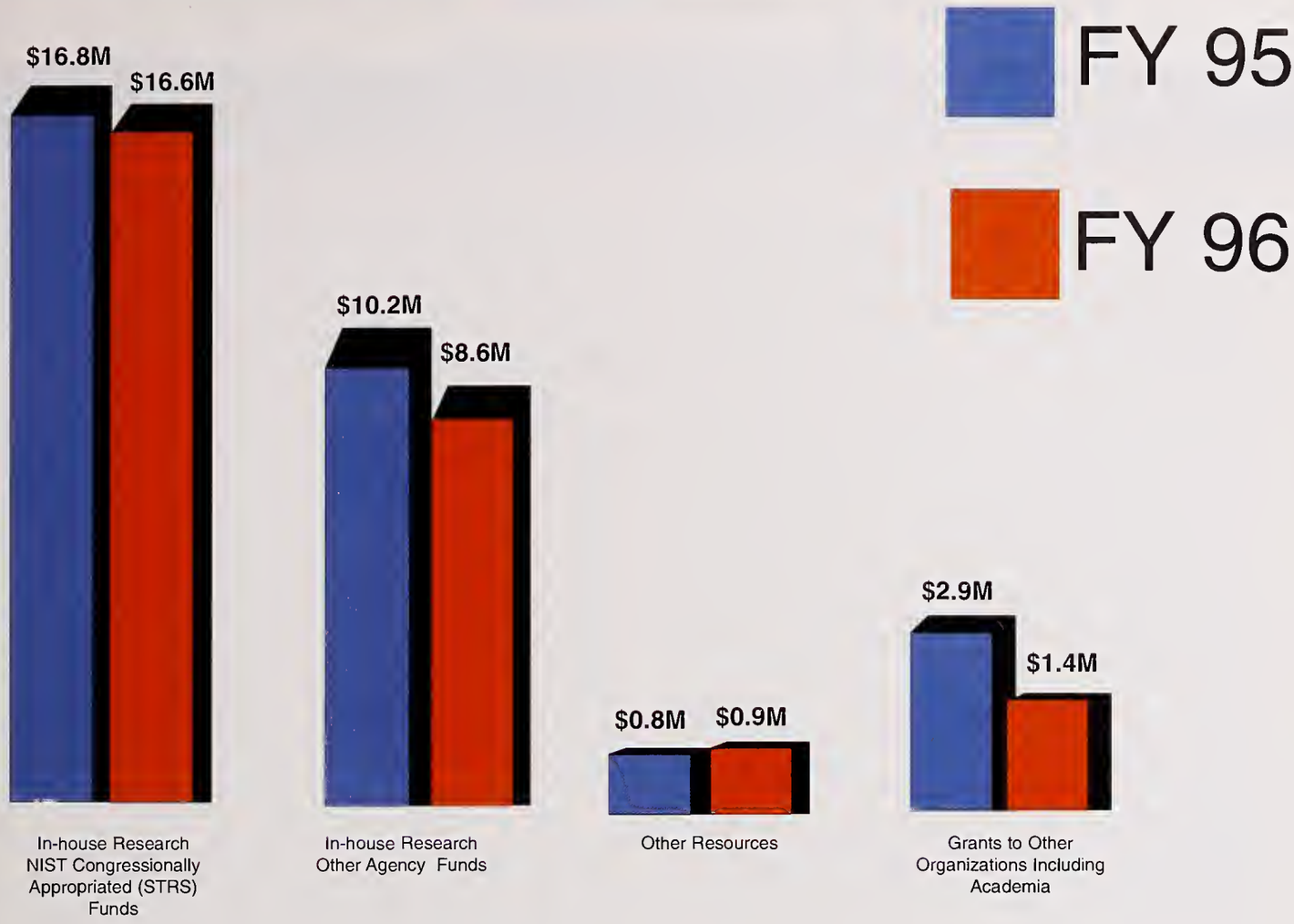
Green Buildings Conference

NIST co-sponsored with the U.S. Green Building Council the Second Annual Green Building Conference in Big Sky, Mon., on August 13-15, 1995. Approximately 300 people attended this conference which featured 27 speakers. The conference focused on the design, construction, operation, maintenance and demolition of buildings in an environmental and cost-effective manner. The conference proceedings were published as NIST Special Publication 888 entitled *Second International Green Building Conference and Exposition – 1995.*

Twenty-Sixth International Symposium on Combustion

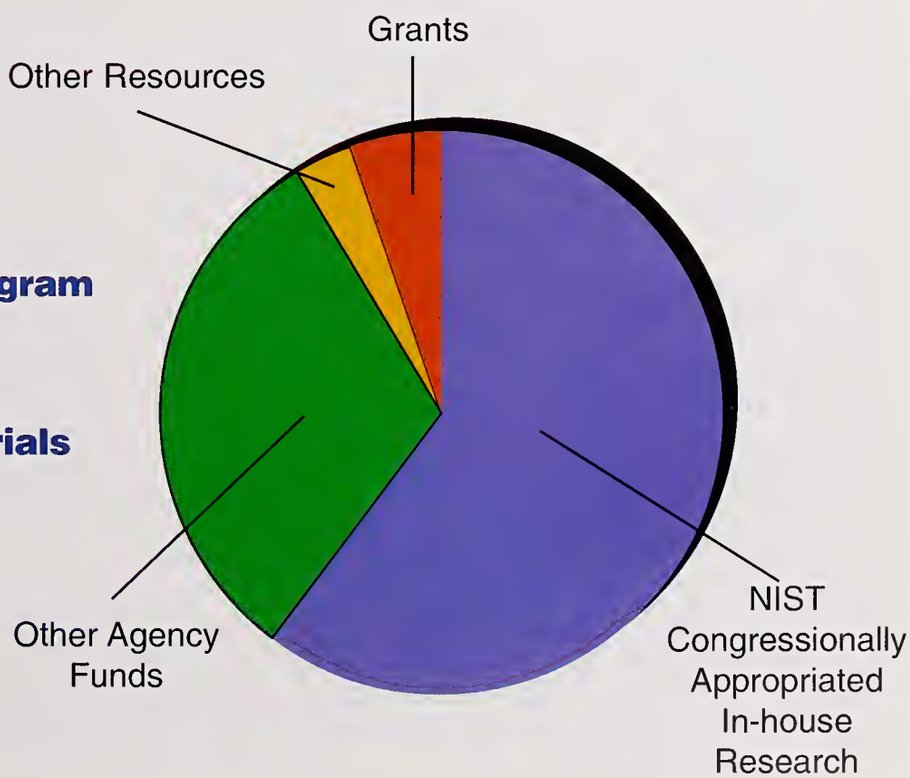
In July 1996, NIST co-sponsored the Combustion Institute's Twenty-Sixth International Symposium on Combustion held in Naples, Italy. The symposium consisted of five days of papers presented in six parallel sessions and seven invited mini-reviews on special topics of current interest. There were 448 general papers and 459 work-in-progress poster papers. NIST staff chaired a number of the sessions and presented 10 technical papers and four posters.

Finances



Note: Other resources include:

Advanced Technology Program
Manufacturing Extension Partnership
Standard Reference Materials
Expense and Income



BFRL ORGANIZATION

The functional statements of the Building and Fire Research Laboratory, and the Offices, Divisions, and Groups in the laboratory are as follows:

BUILDING AND FIRE RESEARCH LABORATORY

Provides the national laboratory concerned with increasing the usefulness, safety and economy of buildings, improving the productivity and international competitiveness of the construction industry, and reducing the human and economic costs of unwanted fires; performs and supports laboratory, field, and analytical research on the performance of construction materials, components, systems and practices; and the fundamental processes underlying initiation, propagation, and suppression of fires; produces technologies to predict, measure, and test the performance of construction and fire prevention and control materials, components, systems, and practices, and to assist the construction and fire safety communities in achieving the benefits of advanced computation and automation; provides research results which are widely used and adopted by governmental and private sector organizations with standards and codes responsibilities, but does not promulgate building or fire safety standards or regulations; and conducts fire research mandated by the Federal Fire Prevention and Control Act of 1974, research for the improvement of seismic design and construction practices as assigned by the Earthquake Hazards Reduction Act of 1977, as amended, and structural failure investigations mandated by the NIST Authorizing Act of FY 1986.

BUILDING AND FIRE RESEARCH LABORATORY OFFICE

Responsible for planning, directing, and implementing the scientific, technical, and administrative programs of the Laboratory through scientific, administrative, and support personnel.

OFFICE OF APPLIED ECONOMICS: Supports the BFRL research and BFRL technology deployment to government agencies and construction and fire-related industries; provides standardized economic methods, economic models, training programs and materials, and expert technical consulting in support of resource allocation decisions; and uses techniques such as benefit-cost analysis, life-cycle costing, multi-criteria decision analysis, and econometrics to evaluate new technologies, processes, government programs, legislation, and codes and standards to determine efficient alternatives.

OFFICE OF TECHNOLOGY TRANSFER : Facilitates the transfer of scientific and technical output of the Building and Fire Research Laboratory to the user community; manages the cooperative building and fire research programs with other federal agencies and national and international private organizations; and develops cooperative research programs with other federal agencies and agencies of foreign governments.

STRUCTURES DIVISION (Chief: Dr. H.S. Lew, 301-975-6061)

Increases the productivity and safety of building construction by providing technical bases for improved structural and earthquake design criteria; conducts laboratory, field, and analytical research in structural engineering which includes: investigation of important structural failures, characterization of normal and extreme loads on buildings occurring during construction and in service, associated structural response and methods for providing desired reliability, development of design criteria for reduction of risks from natural hazards, evaluation methods and criteria for safe and economical construction practices, engineering properties of soils and foundations, and nondestructive evaluation methods and criteria for increasing structural properties.

STRUCTURAL EVALUATION GROUP: Conducts laboratory, field, and analytical research in structural engineering when activities include: development of nondestructive evaluation methods and criteria for assessing structural properties; development of methods for the identification of dynamic response characteristics of flexible members and structural networks; development of technical criteria and methodologies for the strengthening and repair of structural members and systems; characterization of normal and extreme loads on buildings during construction and in service; and investigation of important structural failures.

EARTHQUAKE ENGINEERING GROUP: Provides research data and technical support for the development and application of seismic design and construction practices for new and existing buildings and lifelines when activities include: laboratory and analytical studies needed for improving codes and standards pertaining to new construction; the development of criteria regarding the repair and strengthening of existing structures; the development of procedures to evaluate the response of structural systems to seismic loading; post-earthquake investigations to ascertain the effectiveness of design and construction practices in actual earthquakes; and technical support to the National Earthquake Hazards Reduction Program (NEHRP).

BFRL ORGANIZATION

BUILDING AND FIRE RESEARCH LABORATORY

BUILDING MATERIALS DIVISION (Chief: Dr. Geoffrey J. Frohnsdorff, 301-975-6706)

Advances construction materials science and technology and disseminates improved techniques and data for making decisions concerning construction materials; conducts analytical, laboratory, and field research which includes methods of measurement and prediction of service life, bases for improved criteria and standards for evaluation, selection, use, and maintenance of construction materials, and improved tools to aid the making of decisions concerning construction materials; provides technical support to national and international standards-writing organizations such as the American Society for Testing and Materials (ASTM) and the International Standards Organization (ISO); and conducts cooperative programs with other research organizations, professional societies, standards-writing groups, testing laboratories, and educational institutions.

ORGANIC BUILDING MATERIALS GROUP: Carries out analytical, laboratory, and field research on the performance of organic building materials such as paints and coatings, roofing materials, and sealants and adhesives; provides technical bases for improved criteria and standards for evaluation, selection, and use of these materials; and disseminates improved techniques and data for making decisions on organic building materials, including methodologies for predicting service life.

INORGANIC BUILDING MATERIALS GROUP: Carries out analytical, laboratory, and field research on the performance of cement and concrete and other inorganic building materials such as building stone; provides technical bases for improved criteria and standards for evaluation, selection, and use of these materials; and disseminates improved techniques and data for making decisions on inorganic building materials, including methodologies for predicting service life.

CONSTRUCTION MATERIALS REFERENCE LABORATORIES: Provides technical support for improvement in the quality of construction materials testing, the development of national and international standards, and the advancement of construction materials technology; manages the AASHTO and ASTM-sponsored research associateship programs which (1) provide laboratory inspection and proficiency sample programs, (2) conduct studies to aid in the understanding and improvement of standard methods of test, and (3) support the development of standards by national and international organizations such as ASTM and ISO.

BUILDING ENVIRONMENT DIVISION (Chief: Dr. James E. Hill, 301-975-5851)

Reduces the cost of designing and operating buildings and increases the international competitiveness of the U.S. building industry by providing modeling, measurement, and test methods needed to use advanced computation and automation effectively in construction, and to improve the quality of the indoor environment and the performance of building equipment; conducts laboratory, field, and analytical research on building mechanical and control systems; develops data, measurement methods, and modeling techniques for the performance of the building envelope, its insulation systems, building air leakage, the release, movement and absorption of indoor air pollutants; and develops software performance criteria, interface standards, and test methods needed for the Nation's building industry to make effective use of modern computer-aided design hardware and software, and database management systems.

THERMAL MACHINERY GROUP: Identifies and characterizes new atmospheric-safe refrigerants and refrigerant mixtures that contribute to energy-efficient refrigeration applications; works cooperatively with the Thermophysics Division of NIST in determining the thermophysical properties of the new refrigerants to support industrial design of equipment using these refrigerants; and evaluates alternate refrigeration cycles, systems, and components that will operate efficiently with new refrigerants.

MECHANICAL SYSTEMS AND CONTROLS GROUP: Improves and lowers the cost of building services by fostering the development and use of more intelligent, integrated, and optimized building mechanical systems; develops design tools, diagnostic procedures, and performance evaluation techniques for quantifying the performance of such systems; develops standard communication protocols for exchanging information between building management and control systems (BCMS); and develops the technical bases for advanced building controls which will optimize whole building performance.

HEAT TRANSFER GROUP: Develops basic data and simulation models for heat, air, and moisture transfer through building envelope components and assists consensus standards organizations in the development of appropriate test methods.

COMPUTER INTEGRATED CONSTRUCTION GROUP: Removes technical barriers faced by the construction industry as it integrates its activities using computer technology; provides information interface and performance measurement technologies that support industry development and the use of automated products and services in an integrated environment; develops interface standards, test methods, and performance criteria for integrated project information and control systems; and develops methodologies and computer-

BUILDING AND FIRE RESEARCH LABORATORY

aids for implementing building standards, specifications, and building technology knowledge bases in computer usable forms.

INDOOR AIR QUALITY AND VENTILATION GROUP: Develops measurement and testing procedures, technical data, and comprehensive indoor air quality models to assist in improved indoor air quality and ventilation in buildings.

FIRE SAFETY ENGINEERING DIVISION (Chief: Dr. David Evans, 301-975-6863)

Performs research on and develops engineering methods for fire safety engineers, manufacturers, and other federal agencies to predict the behavior of fire and smoke and assess various means to mitigate the impact of fire on people, property, and the environment. This includes developing and demonstrating the application of analytical tools to building fire problems; developing analytical models for the quantitative prediction of the threats to people and property from fires and the means to assess the accuracy of those models; developing techniques to predict, measure the behavior, and mitigate the impact of large fires; and operating the Fire Research Information Service and the Fire Research large-scale fire test facility.

LARGE FIRE RESEARCH GROUP: Performs research on and develops techniques to measure, predict the behavior of, and mitigate large fire events. This includes: understanding the mechanisms in large fires that control the gas phase combustion, burning rate, thermal and chemical emissions, and transport proceses; developing techniques for computer simulation; developing field measurement techniques to assess the near- and far-field impact of large fires and their plumes; performing research on the use of combustion for environmental cleanup; predicting the performance and environmental impact of fire protection measures and fire fighting systems and techniques; and developing and operating the Fire Research Program large-scale experiment facility.

FIRE MODELING AND APPLICATIONS: Performs research, develops, and demonstrates the application of analytical models for the quantitative prediction of the consequences of fires and the means to assess the accuracy of those models. This includes: developing methods to assess fire hazard and risk; creating advanced, usable models for the calculation of the effluent from building fires; modeling the ignition and burning of furniture, contents, and building elements such as walls; developing methods of evaluating and predicting the performance of building safety design features; developing a protocol for determining the accuracy of algorithms and comprehensive models; developing data bases to facilitate use of fire models; and operating the Fire Research Information Service which serves as a central source of information for the fire community.

FIRE SCIENCE DIVISION (Chief: Dr. Richard G. Gann, 301-975-6864)

Performs research on and develops scientific and engineering understanding of fire phenomena and metrology for fire research; produces principles, metrology, data, and predictive methods for the formation/evolution of smoke components in flames and for the burning of polymeric materials; and develops science and predictive methods to enable high-performance fire detection and suppression systems.

SMOKE DYNAMICS RESEARCH GROUP: Produces scientifically sound principles, metrology, data, and predictive methods for the formation/evolution of smoke components in flames for use in understanding and predicting general fire phenomena which includes: research on the effects of within-flame and post-flame fluid mechanics on the formation and emission of smoke, including particulates, aerosols, and combustion gases; understanding the mechanistic pathway for soot from chemical inception to post-flame agglomerates; and developing calculation methods for the prediction of the yields of CO (and eventually other toxicants) as a function of fuel type, availability of air, and fire scale.

FIRE SENSING AND EXTINGUISHMENT GROUP: Develops understanding, metrology, and predictive methods to enable high-performance fire sensing and extinguishment systems; devises new approaches to minimizing the impact of unwanted fires and the suppression process which includes: research for the identification and in-situ measurement of the symptoms of pending and nascent fires or explosions, and the consequences of suppression; devising or adapting monitors for these variables and creating the intelligence for timely interpretation of the data; determining mechanisms for deflagration and detonation suppression by advanced agents and principles for their optimal use; modeling the extinguishment process; and developing performance measures for the effectiveness of suppression system design.

MATERIALS FIRE RESEARCH GROUP: Performs research to understand fundamentally the mechanisms that control the ignition, flame spread, and burning rate of materials and the chemical and physical characteristics that affect these aspects of flammability; develops methods of measuring and predicting the response of a material to a fire which includes: characterizing the burning rates of charring and non-charring polymers and composites; delineating and modeling the enthalpy and mass transfer mechanisms of materials combustion; and developing computational molecular dynamics and other mechanistic approaches to understand the relationships between polymer structure and flammability.

For Additional Information, contact:

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