Construction and Building:
Federal Research and Development in Support of the U.S. Construction Industry

1995

Subcommittee on Construction and Building
Committee on Civilian Industrial Technology
National Science and Technology Council

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Federal Research and Development in Support of the U.S. Construction Industry

1995

Richard N. Wright, Co-Chair
Arthur H. Rosenfeld, Co-Chair
Andrew J. Fowell, Secretariat

Subcommittee on Construction and Building
Committee on Civilian Industrial Technology
National Science and Technology Council

Abstract

THIS REPORT OUTLINES the Federal strategy for research, development, and deployment in support of the industries of construction, developed with industry by the Construction and Building Subcommittee of the National Science and Technology Council's Committee on Civilian Industrial Technology. The vision is a competitive U.S. industry producing high quality, efficient, sustainable and hazard resistant constructed facilities. Goals for better constructed facilities and improved health and safety of construction workers are described. These have been endorsed by the industry as National Construction Goals. The strategy for reaching the goals involves working closely with all sectors of the industry. Advances in seven areas of technology that have been identified as contributing to meeting the goals for the industry are cited. Examples of important proposed deployment projects that can act as showcases for technology developments are described. A brief summary of the role of member Federal agencies in support of the industry is included.

These superinsulated duplexes look normal but they use only half the space heating energy of conventional houses, saving their owners about *$200 each year. The added costs of insulation, sealing, and low-e windows are offset by eliminating ductwork and downsizing the heating and cooling equipment. The payback time is less than 5 years.*

Construction and Building Subcommittee

Background

The National Science and Technology Council (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 Civilian Industrial Technology (CCIT), to collaborate with the private sector in developing a comprehensive national technology policy. The purpose of CCIT is to enhance the international competitiveness of U.S. industry through Federal technology policies and programs. The Subcommittee on Construction and Building (C&B) of CCIT coordinates and defines priorities for Federal research, development, and deployment related to the industries that produce, operate, and maintain constructed facilities, including buildings and infrastructure.

Member Agencies

Agencies (listed below) participating in the Subcommittee include agencies with responsibilities as owners and operators, regulators, and researchers.

Department of Agriculture (Forest Service)

Department of Commerce, Co-chair (National Institute of Standards and Technology)

Department of Defense (Corps of Engineers)

Department of Energy, Co-chair

Department of Health and Human Services (National Institute for Occupational Safety and Health)

Department of Housing and Urban Development

Department of Interior (U.S. Bureau of Mines) (U.S. Geological Survey)

Department of Labor (Occupational Safety and Health Administration)

Department of Transportation (Federal Highway Administration)

Department of Veterans Affairs

Consumer Products Safety Commission

Environmental Protection Agency

Federal Emergency Management Agency

General Services Administration

National Aeronautics and Space Administration

National Science Foundation

Mission

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, for improvement of the life cycle performance of constructed facilities. C&B addresses Administration goals to:

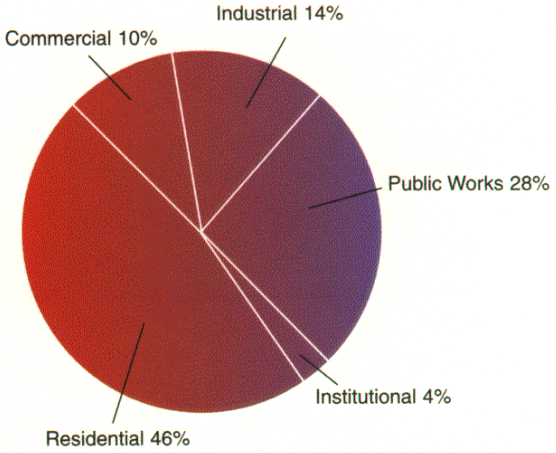
- Forge partnerships with industry to strengthen America's industrial competitiveness and create jobs.
- Make environmental protection, safety, and energy efficiency fully consistent with other business objectives.

The Construction Industry

Construction is one of the Nation's largest industries and a critical asset for enhancing the international competitiveness of U.S. industry. In 1994, new construction and renovation combined amounted to $850 billion, about 13 percent of the GDP, and provided employment for over 10 million persons. Constructed facilities shelter and support most human activities. Their quality is vital to the competitiveness of all U.S. industry, the safety and quality of life of the people, and environmental quality.

New Construction

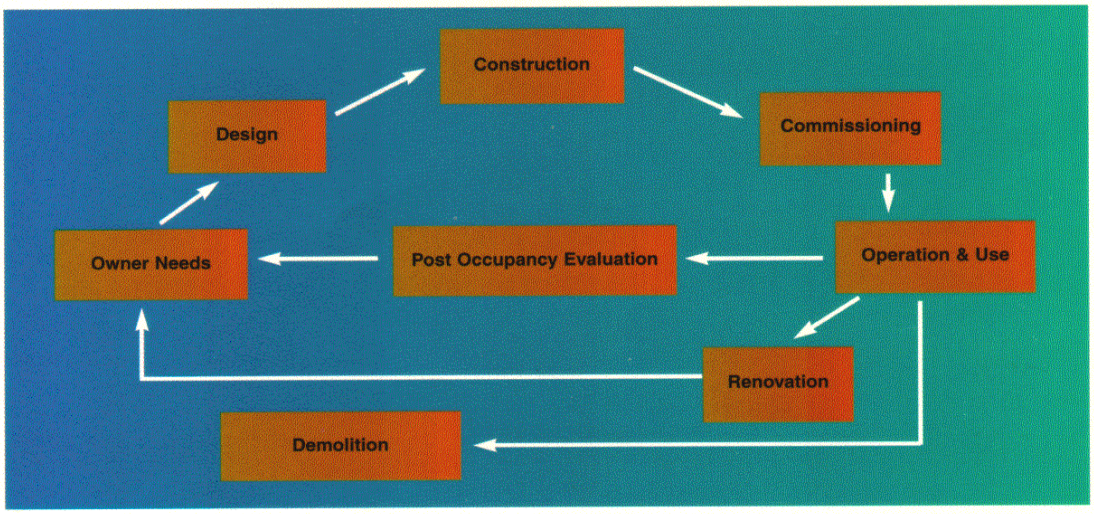
New construction put in place in 1994 represents about $508 billion (which is about 60 percent of the total construction market). The breakdown between the five sectors of the industry; residential, commercial, industrial, institutional, and public works is shown in the adjacent pie chart.

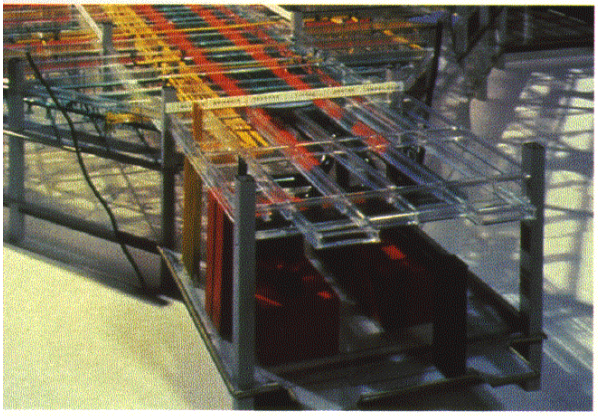


Life Cycle of Constructed Facilities

Construction includes the whole life of the project: initial planning and programming, design, procurement, construction, occupancy and maintenance, condition assessment, retrofit and renovation or removal. This whole life viewpoint is necessary to give realistic attention to values and costs of constructed facilities. For instance, for an office building, the annual operating cost, including salaries of occupants, roughly equals the initial construction cost. The primary value comes from the productivity of the occupants, which depends on the capability of the building to meet user needs throughout its useful life. Some technical innovations in facilities, such as those for durability, efficiency, or improved safety against natural disasters, may add to the initial cost but reduce the life cycle cost. Different sectors of the industry and their customers place different emphases on the importance of life cycle cost.

Life Cycle of Constructed Facilities.





Industries of Construction

Construction involves many industries including:

Architectural and engineering design

Construction

Construction equipment manufacture

Materials manufacture

Installed equipment manufacture

Furnishings manufacture

Maintenance and repair

Demolition

Finance

Insurance

Facility management

Security

Cleaning services

Fire protection

Vision

The vision for the construction and building industries is:

Competitive — High quality constructed facilities support the competitiveness of U.S. industry and everyone's quality of life.

High Quality — U.S. industry leads in quality, speed and economy in the global market for construction products and services.

Efficient and Sustainable — The construction industry and constructed facilities are energy efficient, sustainable in use of resources, safe and healthful.

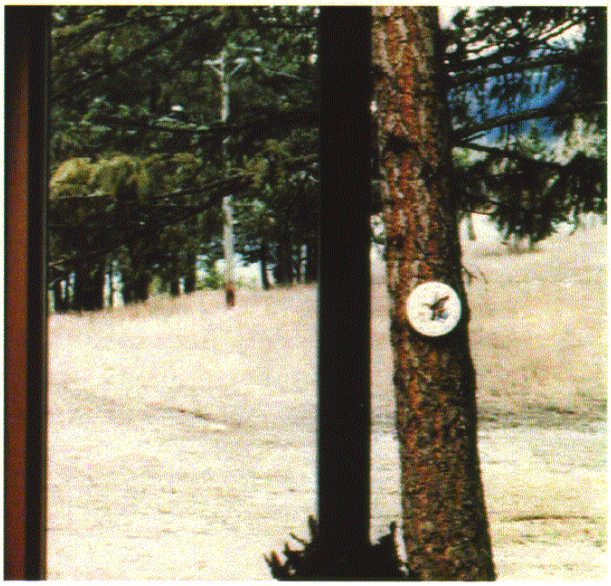
Hazard Resistant — Natural and manmade hazards do not cause disasters.

National Construction Goals

The C&B Subcommittee has studied research priorities expressed by the construction industry in industry fora 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 make technologies and practices capable of achieving the goals under these thrusts available for general use in the construction industry by 2003. The baseline for measuring progress against the goals will be today's business practices. Therefore, reliable baselines need to be established, and measurement tools developed.

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 on April 5, 1994, by the Civil Engineering Research Foundation. These leaders strongly endorsed the goals.



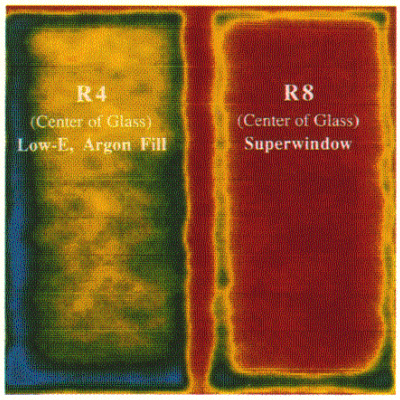
Low-E windows not only have excellent thermal performance, but they are affordable and are now used in 40% of residential windows only 13 years after market introduction.

Goals - Rationale

Better Constructed Facilities

50% Reduction in Delivery Time

Reduction in the time from the decision to construct a new facility to its readiness for service is vital to industrial competitiveness and project cost reduction. During the initial programming, design, procurement, construction and commissioning process, the need of the client for the facility is not being met; needs evolve over time so a facility long in delivery may be uncompetitive when it is finished; and the investments in producing the facility cannot be recouped until the facility is operational. The need for reduction in time to project completion is often stronger in the case of renovations and repairs of existing facilities because of interruption of ongoing business. Owners, users, designers and constructors are among the groups calling for technologies and practices reducing delivery time.



High tech, thin film "low-E" coatings have revolutionized the energy efficiency of windows. Adding one coating and a gas fill to conventional double glazing cuts the heat loss by 50%; added two coatings in a triple pane window cuts the losses by another 50%. These two windows appear identical to the homeowner, but when viewed with an infrared thermographic camera that visualizes heat loss (right false color image) the differences between the two glazings is apparent.

50% Reduction in Operation, Maintenance and Energy Costs

Operation and maintenance costs over the life of the facility usually exceed its first cost and may do so on an annualized cost basis. To the extent that prices for energy, water, sewage, waste, communications, taxes, insurance, fire safety, plant services, etc., represent costs to society in terms of resource consumption, operation and maintenance costs also reflect the environmental qualities of the constructed facility. Therefore, reductions in operation and maintenance and energy costs benefit the general public as well as the owners and users of the facility.

High-strength composites can be made from recycled wood, newspaper, plastics and other materials. This air-laid web process results in flexible mat that can be molded into a variety of complex shapes.

30% Increase in Productivity and Comfort

Industry and government studies have shown that the annual salary costs of the occupants of a commercial or institutional building are of the same order of magnitude as the capital cost of the building. Indeed, the purpose of the building is to shelter and support the activities of its occupants. Improvement of the productivity of the occupants (or for an industrial facility, improvement of the productivity of the process housed by the facility) is the most important performance characteristic for most constructed facilities.

50% Fewer Occupant Related Illness and Injuries

Buildings are intended to shelter and support human activities, yet the environment and performance of buildings can contribute to illnesses and injuries for building users. Examples are avoidable injuries caused by fire or natural hazards, slips and falls, legionnaires' disease from airborne bacteria, often associated with a workplace environment (sick building symptoms) and building damage or collapse from fire, earthquakes, or extreme winds. Sick building symptoms include irritation of eyes, nose and skin, headache and fatigue. If improvements in the quality of the indoor environment reduce days of productive work lost to sick days and impaired productivity, annual nationwide savings could reach billions of dollars. Criminal violence in buildings is a safety issue which can be addressed in part by building design. Reductions in illnesses and injuries will increase users' productivity as well as reducing costs of medical care and litigation.

50% Less Waste and Pollution

Improvement of the performance of constructed facilities that shelter and support most human activities, provides major opportunities to reduce waste and pollution at every step of the delivery process, from raw material extraction to final demolition and recycling of the shelter and its contents. Examples are reduced energy use and greenhouse gas emissions and reduced water consumption and waste water production. Waste and pollution also can be reduced in the construction process: construction wastes are estimated at 20-30 percent of the volume of landfills.

50% More Durability and Flexibility

Durability denotes the capability of the constructed facility to continue (given appropriate maintenance) its initial performance over the intended service life, and flexibility denotes the capability to adapt the constructed facility to changes in use or users' needs. High durability and flexibility contribute strongly to the life cycle quality of constructed facilities since they usually endure for many decades.

Health and Safety of Construction Workforce

50% Reduction in Construction Work Illnesses and Injuries

A factor affecting international competitiveness is the cost of injuries and diseases among construction workers. Although the construction workforce represents about 6 percent of the Nation's workforce, it is estimated that the construction industry pays for about one-third of the Nation's workers' compensation. Workers' compensation insurance premiums range from 7 to 100 percent of payroll in the construction industry. Construction workers die as a result of work-related trauma at a rate that is 2½ times the annual rate for workers in all other industry sectors (13.6 deaths per 100,000 construction workers, as compared to 5.5 deaths per 100,000 workers in all other industry sectors). Construction workers also experience a higher incidence of nonfatal injuries than workers in other industries.

Strategy

To help the construction and building industries meet the above goals, the member Federal Agencies of C&B will:

Work with industry

Provide baselines and measures of performance

Focus Federal R&D programs on automation, high performance materials and systems, measurement, and sustainability

Provide tools for a more efficient regulatory process

Provide tools for acceptance of innovation

Use Federal construction for technology demonstration

Set goals and milestones for the program and measure effectiveness

Working with Industry

White House Construction Industry Workshop on National Construction Goals.

The Construction and Building Subcommittee's program and goals were reviewed with a focus group of industry leaders convened on April 5, 1994, by the Civil Engineering Research Foundation. The response of the focus group is described in the Construction Industry Whitepaper "Innovation in the U.S. Construction Industry: An Essential Component for America's Economic Prosperity and Well Being." The white paper is an industry perspective of methods and means that, if jointly supported and implemented by the public and private sector, promise to transform the construction sector into the high technology/high skill sector America requires. Construction industry leaders strongly endorsed the goals established by C&B. The industry leaders urged expanded dialogue and the immediate initiation of actions.

On December 14-16, 1994, industry leaders held a White House Construction Industry Workshop on National Construction Goals organized by the Civil Engineering Research Foundation. The workshop's purpose was to provide an industry perspective on the priorities among proposed construction goals and develop recommendations for an appropriate implementation plan. Participants in the workshop included representatives from design, construction, labor, construction equipment, building materials and mechanical equipment, finance, insurance, owners, codes, etc.

Industry Perspective

The results of the White House Construction Industry Workshop are reported in a CERF report, "National Construction Goals: A Construction Industry Perspective." The workshop noted that the five sectors of the construction industry: residential, commercial, industrial, institutional, and public works differ in the participants involved, methods of financing, legal factors, project timing, the desire for or acceptance of innovation,

Sector Goal	Res	Com	Inst	Ind	Pub.Works	Rank
Delivery Time	xx	x	xx	xx	x	1
Operation, Maintenance, and Energy	x	xx	x	x	xx	2
Productivity and Comfort		x	x			5
Occupant Health and Safety	x					6
Waste and Pollution	x				x	5
Durability and Flexibility	xx	x			x	3
Worker Health and Safety	x		x	x		4

the importance first cost or operating cost, market forces, and customer involvement. Consequently, they differ in their ranking of relative importance of the proposed goals. For example, residential construction

specifically identified reduced first cost (directly coupled to reduced delivery time) as their most important goal. Goals that are considered of highest priority to the industry are identified in the chart (**xx**), and those of lessor priority with (**x**).

Meeting the goals will require advances in technology, demonstration of those advances, and leadership to bring about the important non-technical changes called for by industry. Lack of present knowledge makes less feasible the important goals for Productivity and Comfort, and Occupant Health and Safety. The workshop encouraged research in these important areas to make advances toward these goals possible in the near future.

Non-Technical Barriers

At the April 1994 meeting of the focus group, the construction industry took note of the following major non-technical barriers to the introduction of technical innovations:

Lack of Leadership

Regulatory Barriers

Liability

Adversarial Relations, and

Financial Disincentives

The following additional barriers were cited by industry at the December 1994 Workshop:

Parochialism

Increasing Scarcity of Skilled Labor

Fragmentation of the Industry

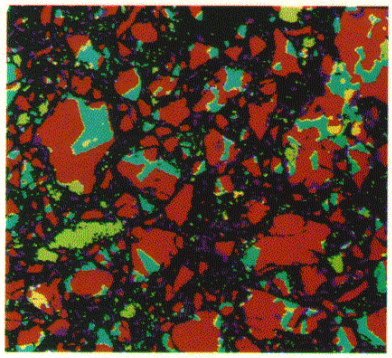
Inadequate Owner Involvement

"Barriers are pervasive and more than anything else prevent or retard the application of badly needed innovation in the construction industry."

Barrier Removal

Industry representatives identified a number of changes needed to remove barriers to private sector investments in technology required to meet the goals.

- a speed-up in the regulatory process, i.e., obtaining the necessary approvals,
- tort reform to avoid unreasonable liability from using innovations,
- performance standards and conformance assessment mechanisms to enable users and regulators to assess and accept new materials, products, and systems,
- education of builders, managers, regulators in information systems and data, and training of craft workers to increase the pool of skilled labor and to promote safe operating practices,
- a closer working relationship between all parties in the facility design and construction process, particularly in the early stages of planning and design, and
- formation of a construction coordination council that would guide private activities and speak for the industry to bring about some of the needed changes in the system.



Output of a computer model that simulates the development of the microstructure of concrete during the setting process. Models like this are used to predict concrete performance, strength and durability.

Technology Advances

Advances in seven areas of technology have been identified as contributing to a more competitive construction industry and helping to meet the goals for the industry.

1. Information and Decision Technologies

Integrated data bases and information systems

Knowledge systems as successors to standards and books

Integrated project information systems

Construction management technologies

Collaborative decision making environments

Post-occupancy evaluation systems

2. Automation in Design, Construction and Operation

Simulation and visualization

Computer-aided design

Computer-integrated construction

Advanced sensors

Construction robotics

Building automation systems

Computer-aided facilities management

All-weather construction

3. High Performance Materials, Components, and Systems

- Advanced materials
- Advanced components
- Whole building systems
- Connections
- Mechanisms, models and data for life cycle performance
- Assessment and quality assurance technologies
- Renewal engineering
- Recycling and reuse
- Functional flexibility
- Improved water sealants
- UV barriers

4. Environmental Quality

- Energy conservation
- Indoor air quality
- Remediation of contaminated construction sites
- Sustainable development (ecological quality, conservation of non-renewable materials, etc.)

5. Risk Reduction Technologies

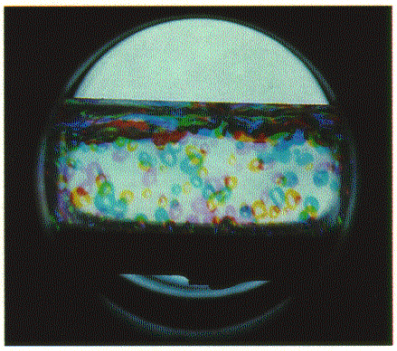
- Fire protection
- Toxic exposures
- Earthquake risk reduction
- Wind risk reduction
- Other hazards

6. Performance Standards System

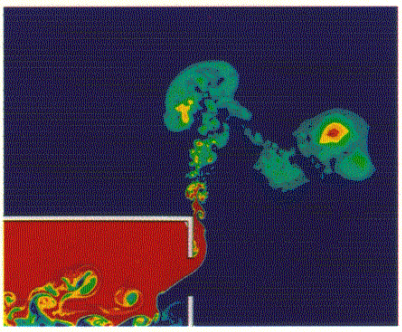
- Performance standards for products and processes
- Test methods and data for life cycle performance
- Conformance assessment system
- Certification system
- Data bases availability and accessibility

7. Human Factors

- Cognitive processes and uses of information
- Physiology
- Ergonomics
- Environmental and person-machine interactions
- Team building and workforce efficiency



Measurements of the nucleate boiling heat transfer characteristics on refrigerants being tested as alternatives to chlorofluorocarbons.



NIST is developing numerical techniques to evaluate the flow of smoke and hot gases released by fires.

Plan for Deployment

Barriers to the acceptance of new technology include the lack of knowledge of what is available, the benefits to be gained, the risks involved in initial uses of new technologies, and simply human resistance to change. A key part of this multi-agency program is the showcasing of new technologies and methods for overcoming barriers. Federal construction and renovation projects provide an excellent showcase for these innovations, and enable all stakeholders to gain comfort with change.

Executive Order 12902, Energy Efficiency and Water Conservation at Federal Facilities, of March 8, 1994, requires that when an agency constructs at least five buildings in a year, it shall designate at least one building, at the earliest stage of development, to be a showcase highlighting advanced technologies and practices for energy efficiency, water conservation, or use of solar and other renewable energy. The order also requires that each agency designate one of its major existing buildings to become a showcase to highlight energy or water efficiency and attempt to incorporate solar and other renewable technologies, and indoor air quality improvements. Each agency is required to develop and implement plans and work in cooperation with the Department of Energy, and where appropriate, in consultation with the General Services Administration and other appropriate agencies to determine the most effective and cost effective strategies to implement these demonstrations. Efforts of the C&B Subcommittee can facilitate visibility for these projects and help underscore their significance to the housing and construction industries.

First completed in 1905, San Francisco's historic U.S. Court of Appeals Building survived two major earthquakes – in 1906 and 1989. Following the 1989 Loma Prieta earthquake, which significantly damaged the building, GSA Pacific Rim Region and the Administrative Office of the Courts for the Ninth Circuit decided to undertake a full-scale seismic upgrade of the building structure, together with its repair, renovation and expansion.

Deployment: Significant Current Demonstration Projects

U. S. Court of Appeals, San Francisco, California. (GSA/NSF)

The Ninth Circuit U.S. Court of Appeals, damaged in the 1989 Loma Prieta earthquake, is being retrofitted with seismic isolation, additional shear walls and diaphragm strengthening. Friction Pendulum System bearings used for base isolation were developed with support from a grant from NSF.

IBACOS Reference and Laboratory Houses, Pittsburgh, Pennsylvania. (DOE)

IBACOS, a consortium of architects, builders, material suppliers and component suppliers, has completed 2 two story, four bedroom houses. One will demonstrate integrated new technologies that will be commercially available in one to three years such as combined wall construction, heating, ventilating and air quality systems, plumbing and energy efficient shell/panel concepts designed, manufactured and installed as a system.

Exemplary Buildings (DOE)

Four highly efficient passive solar residences are being built in California, Kentucky, Virginia and Arizona. These buildings will use about half the energy of typical residences.

Walnut Creek National Wildlife Refuge Learning Center, Prairie City, Iowa. (DOI/NIST)

A complex group of environmentally sustainable buildings will be earth bermed, double glazed, have natural lighting, have R30 insulation, and a specifically constructed wetland septic system.

High Strength Concrete Bridge, Texas. (FHWA)

The bridge will be built from 89.7 MPa(13000 psi) concrete rather than the usual 41.4 MPa (6000 psi) material which is expected to save 20 percent on construction costs, require lower maintenance and provide longer service life.

EPA Headquarters, Waterside Mall, Washington D.C. (EPA)

The building is being retrofitted with a real-time environmental monitoring system which communicates through a proprietary local area network. Being considered as part of the retrofit are gas absorption cooling, desiccant cooling.

Flaw Detection Instrument for Concrete. (NSF, NIST)

This instrument currently undergoing application investigations is based on the principle of evaluating the echo response to an imposed impact. The instrument detects flows, voids and the location of reinforcing bars.

Connecticut Road Industry Surveillance Project. (NIOSH)

This is designed to prevent lead toxicity in bridge workers. Results have shown a continuous drop in blood lead levels from 36 ug/dl in 1991 to nearly 10 ug/dl.

Highway Innovative Technology Center. (HITEC, FHWA, Private Sector)

HITEC, a service center of the Civil Engineering Research Foundation supported by FHWA, evaluates products for use in any aspect of the highway system. HITEC expedites the introduction and use of new products, establishes product performance benchmarks, fosters public-private sector collaboration, reduces duplication by relying on existing research, testing, and evaluation facilities, and reduces overall evaluation implementation costs.

Best Practices for Construction Safety. (NIOSH/Center to Protect Workers Rights)

A project on the development of guidelines for industry best practices for construction safety is in its second year as part of a joint construction initiative between the Center to Protect Workers Rights and the National Institute for Occupational Health and Safety. The completion and dissemination of these guidelines in the summer of 1995 will help to meet the milestone for the health and safety of construction workers.

As the Federal Government's first, and the world's largest, base isolation seismic retrofit project, the U.S. Court of Appeals posed special challenges. The size and weight of the building made the issue of cost versus seismic performance critical to the feasibility of the project. At the same time, the architectural significance of the U.S. Court of Appeals Building and its importance to the U.S. Courts in San Francisco made the issues of seismic performance and impact on the historic building equally critical. To work, the solution had to resolve all three issues in an optimal manner. The use of innovative base isolation technology provides seismic safety at a cost less than the alternative, traditional technologies.

Deployment: New projects for FY 95/96

Important proposed deployment projects for FY95 and FY96 are:

NIST's Manufacturing Extension Partnership

Construction technology is proposed as part of the outreach effort at many of the Manufacturing Technology Centers sponsored by NIST. These centers provide information on new manufacturing technology to smaller manufacturers.

National Building Product Testing, Evaluation, and Approval System

This system will include the testing and certification of all new and innovative building materials and products used for all types of construction and will incorporate features of the current HUD "Technical Suitability of Products Program" for evaluation and acceptance of materials, components, and structural systems used for HUD-FHA residential construction.

PlantSTEP Consortium to Build Information Exchange Technology for Process Plants

Eleven companies will raise the capability of U.S. firms to compete in the world process market by making sure that they and all U.S. firms (suppliers, fabricators etc.) can share information seamlessly. STEP is the international standard for the exchange of product model data.

Golden Gate Federal Building, San Francisco, California

This large GSA operated building will be used to demonstrate the viability of BACnet as an open system communication protocol for Energy Monitoring and Control Systems (EMCS). The project will also facilitate the development and implementation of advanced control concepts involving fault detection, diagnostics, and building system optimization.

Refrigerant Conversion Demonstration

A cold storage plant in Ft. Jackson, South Carolina, will be converted from R-12 to R-134a. This will demonstrate the use of environmentally safe refrigerants in commercial size refrigeration and air conditioning systems. The USACERL will monitor performance of the converted system.

Federal Construction R&D Budget ($ Million)

The Administration has assigned priority for research and development to Construction and Building for the FY 96 budget as "Activities that support the residential/commercial building construction industry and its suppliers in the development of advanced technologies aimed at increasing the productivity of construction, improving product quality (including energy efficiency and improved indoor air quality), use of renewable resources, and increased worker health and safety."

The following table reflects the changes proposed in the President's budget for construction R&D for FY 96 compared with the budget enacted for FY 95.

Agency	FY 95*	FY 96**
Dept. of Energy	59.5	63.9
National Science Foundation	55.0	57.3
Dept. of Commerce (NIST)	16.9	22.9
Dept. of Defense (Army Corps of Engineers)	0	15.8
Dept. of Agriculture	7.9	7.4
Dept. of Housing and Urban Development	2.0	2.0
TOTAL	**141.3**	**169.3**

* FY 95 enacted budget ** FY 96 President's budget request

NOTE 1: In addition to the above budget figures, many agencies have C&B related research and development listed primarily for other NSTC activities, for instance, the National Institute of Occupational Safety and Health , Department of Health and Human Services, budgeted $14.3 million to construction worker and building occupant safety and health in FY 95 and FY 96.

NOTE 2: Other Federal agencies including the General Services Administration and the Department of Veterans' Affairs are involved in the deployment of new technology in construction but do not budget funds for construction research and development.

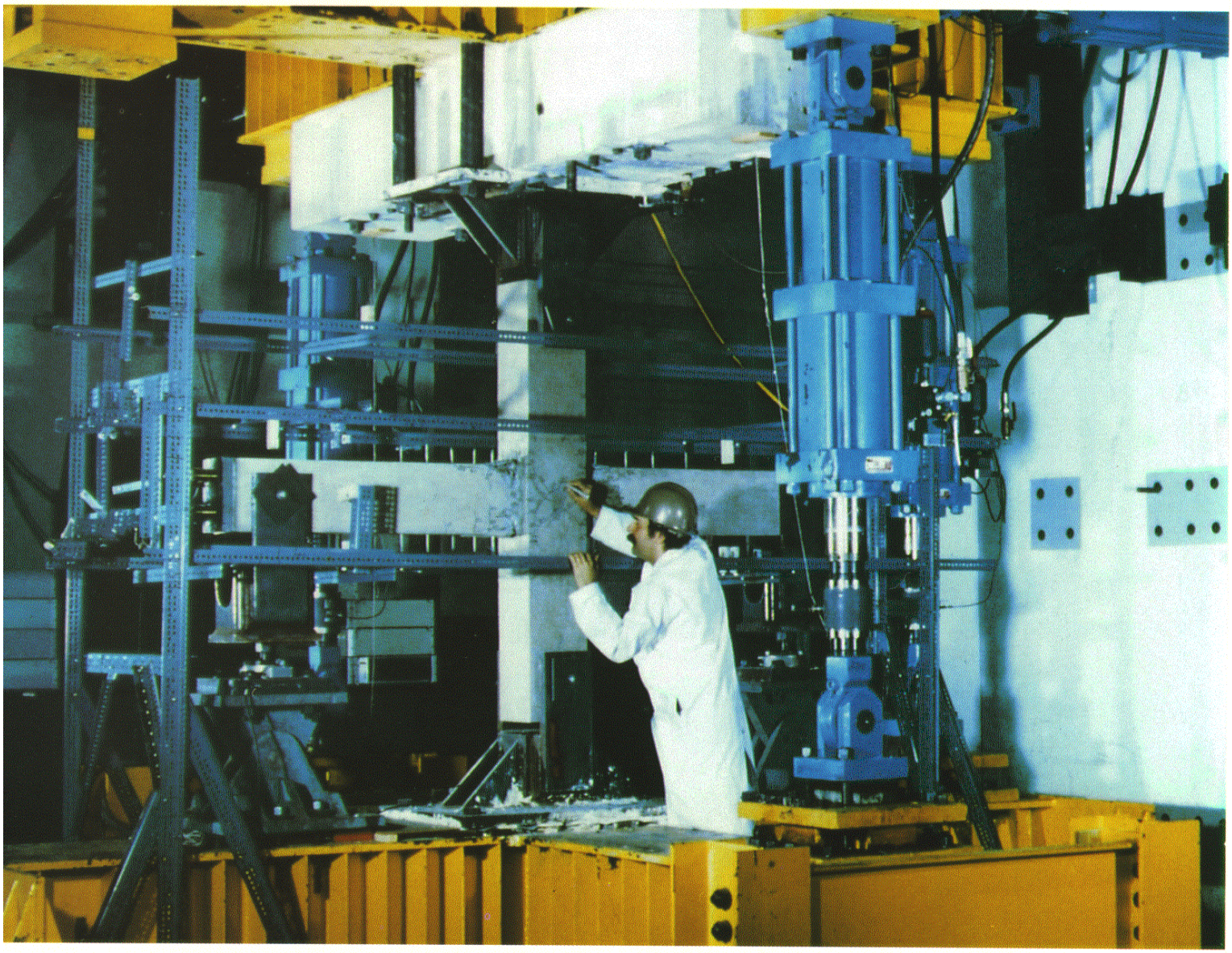
The USDA Forest Service, Forest Products Laboratory, uses this three-dimensional structural test frame to investigate the technical feasibility of wood structural systems that resist wind and earthquake load and can be constructed quickly.

Individual Agency Programs

The following section describes the mission and activities contributing to the construction and building program of each Federal agency participating in the Subcommittee on Construction and Building. A contact person is identified for each agency.

Note: Consumer Product Safety Commission, U.S. Geological Survey, and the Federal Emergency Management Administration have only recently joined the Subcommittee and did not have the opportunity to develop a description of agency mission and activities before this publication went to press.

Innovative precast beam-column connections undergoing earthquake motion tests.

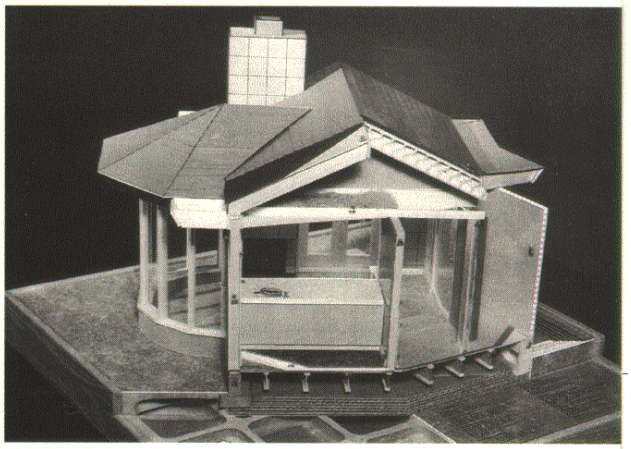


U.S. Department of Agriculture

Forest Service, Forest Products Laboratory
Madison, WI 53705

Mission:

The USDA Forest Service's natural resource stewardship responsibilities include ensuring the wise and efficient use of our Nation's forests. As part of that responsibility, the Forest Service conducts research to develop technology that helps meet America's growing demand for forest products, conserve our Nation's forests, and improve the environmental sensitivity of forest products manufacturing. Within that framework, a Forest Service research initiative is aimed at increasing the use of recycled wood and paper in housing.



This model house depicts the use of new recycled wood and paper products for housing. Use of recycled products has the potential to conserve resources, reduce land-fills, provide additional supplies of construction materials, and create jobs.

Major Activities Contributing to the Construction and Building Program:

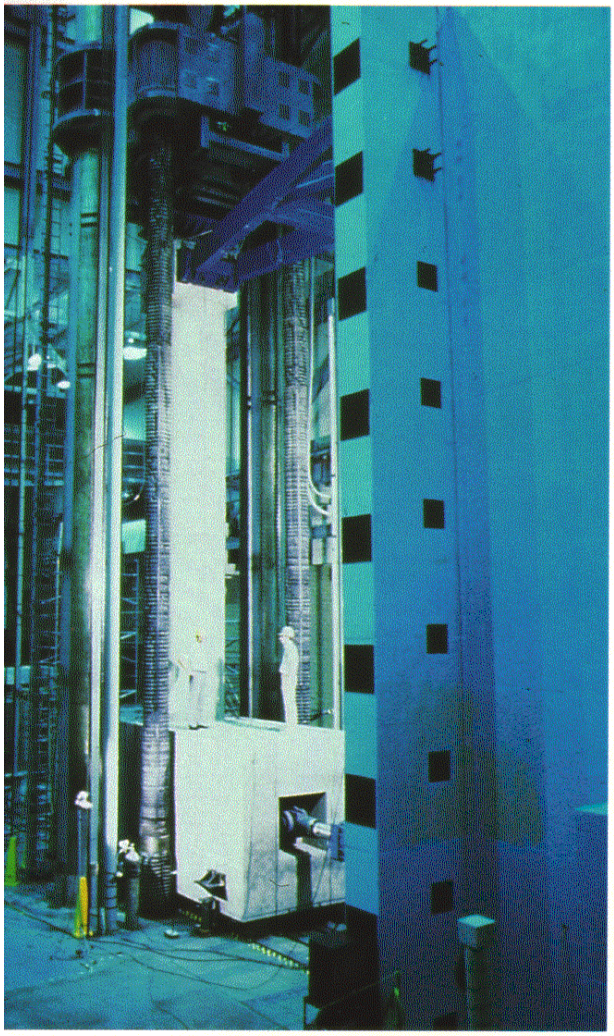
- Develop processing technologies that increase efficiency, minimize environmental impacts, and improve utilization of wood wastes.
- Provide technical basis for performance characteristics of wood products used in housing.
- Identify test procedures and criteria for development of codes and standards for new wood products.
- Determine economic feasibility and impacts of emerging technologies in the wood products sector.
- Facilitate implementation of new technologies of with industrial partners.

Contacts:

Thomas Hamilton, Director, Forest Products Laboratory,
One Gifford Pinchot Drive, Madison, WI 53705.
Tel: (608) 231-9200, Fax: (608) 231-9567

Hao Tran, Forest Products and Harvesting Research,
USDA Forest Service, 14th & Independence, Washington, D.C. 20090.
Tel: (202) 205-1565, Fax: (202) 205-2497
E-mail: fswa/s=h.tran/ou1c@mhs.attmail.com

Department of Commerce
National Institute of Standards and Technology
Gaithersburg, MD 20899



Large-scale test structures facility. With its 53 MN (12 million pound) universal structural testing machine – the largest in the world – this facility can test structural components up to 17.7 m (58 ft) in height.

Mission:

NIST's Building and Fire Research Laboratory (BFRL) is dedicated to improving the life cycle quality of constructed facilities. Its performance prediction and measurement technologies enhance the competitiveness of U. S. industry and public safety. The laboratory studies structural, mechanical, and environmental engineering, fire science and fire safety engineering, building materials, and computer integrated construction practices.

Major Activities Contributing to the Construction and Building Program:

- Develops technologies to predict measure and test the performance of construction materials, components, systems, and practices.
- Provides the technical basis for integrated automation and robotics in the construction process, supporting industry's development of automated constructed facilities, and reducing injuries to the construction workforce.
- Provides world leadership in new technologies for earthquake and wind hazard reduction.
- Develops the underlying technical support for new safety standards, and generates the engineering methodology to support the practice of fire protection engineering.
- Develops measurement methods to define the performance of advanced building environmental systems.

Contact:

Richard N. Wright, Director, Building and Fire Research Laboratory, NIST
Tel: (301) 975-5900, Fax: (301) 975-4032
E-mail: wright@micf.nist.gov

Department of Defense

Defense Research and Engineering
Washington, D.C. 20301

Civil Works Research & Development Program

Mission:

The Department of Defense administers the Civil Works (CW) Research & Development (R&D) program to provide solutions to problems related to the Corps of Engineer's Civil Works Program. The CW R&D is highly applied research utilizing products and techniques developed by industry and universities and adapting them to civil works needs. Research in six areas of the Civil Works R&D program contribute to the goals of the Construction & Building R&D Program.

Civil Works Hydroelectric Dam

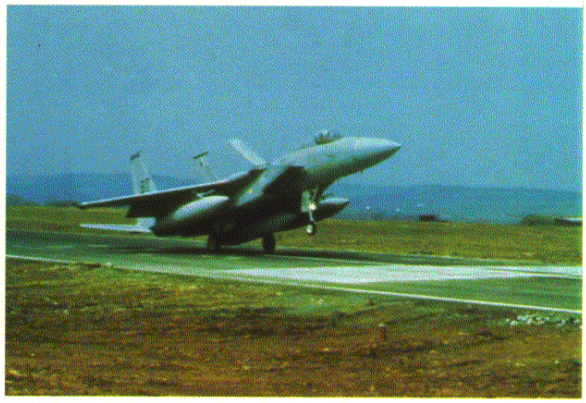
Major Activities Contributing to the Construction and Building Program:

- Materials research
- Coastal structure evaluation and design
- Flood control structures research
- Repair, evaluation, maintenance and rehabilitation
- Construction productivity research
- Earthquake engineering research

Military Research & Development Program

Mission:

The primary goal of the DoD civil engineering research program is to support the national security objectives of the nation by conducting research to enhance the life cycle performance of the infrastructure required to provide an efficient and cost effective power projection platform for the armed forces. The DoD Reliance program has eliminated redundant military research and development programs and capabilities and has increased interdependence among the military services for Civil Engineering Science and Technology R&D. Five Civil Engineering Reliance R&D focus areas contribute to the goals of the Construction and Building R&D program.



Military Airfield

Major Activities Contributing to the Construction and Building Program:

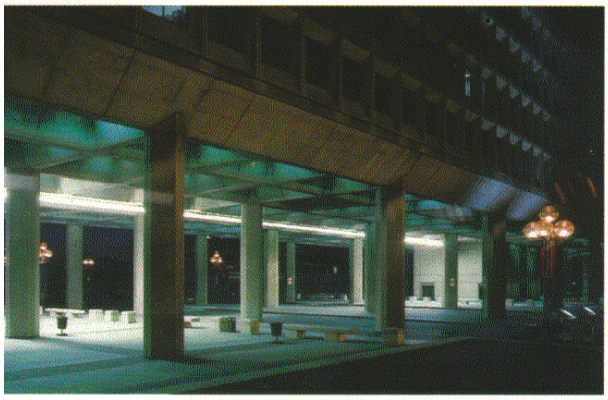
- Conventional facilities
- Airfields and pavements
- Fire fighting
- Ocean and waterfront facilities/operations
- Critical airbase facilities/recovery

Contact:

Thomas Rutherford, Office of the Under Secretary of Defense
for Research and Engineering
Tel: (703) 756-0997, Fax: (703) 756-7648
E-mail: trutherf@acg.osd.mil

Department of Energy

Office of Building Technology
Washington, D.C. 20585



A new lighting system, unveiled in October 1994, demonstrates a new sulfur lamp invented, designed and built by Fusion Lighting, Inc., of Rockville, MD, under contract to the U.S. Department of Energy.

In the Forrestal Building application, the 240 foot-long light pipe powered by a single electrodeless sulfur bulb at each end with a total power of only 12 kW has replaced 240 conventional mercury high-intensity discharge (HID) 200-watt lamps, drawing 50kW, so power saving is 75%. The environmental saving in primary energy or CO_2 offsets the emission of 50 cars.

Mission:

The building sector, including both residential and commercial buildings, currently uses 30 quadrillion BTU's of primary energy annually. This is 35 percent of total U.S. energy consumption, and includes 65 percent of all electricity used in the U.S. Federally owned facilities represent approximately 2 percent of U.S. building stock. The mission of Office of Building Technologies (OBT) is to limit the expected increase in building sector energy consumption by improving energy efficiency and expanding the use of renewable energy in buildings. Recent analysis has shown that the growth in demand for energy services in buildings can be met without increasing total energy use. Increased emphasis in market-pull activities has been the result of the Energy Policy Act of 1992 and the Climate Change Action Plan of 1993.

Major Activities Contributing to the Construction and Building Program:

- OBT conducts a comprehensive research program designed to develop, demonstrate and, if appropriate, commercialize advances in energy performance of major building components including thermal insulation systems, windows, and heating and cooling equipment.
- Additionally, OBT conducts a program that focuses on the activities of market-pull and market transformation of energy efficient buildings systems. This includes many of the activities recently authorized by Energy Policy Act and the Climate Change Action Plan: for example, "Rebuild America" is a program directed at upgrading the energy performance of the existing stock of commercial buildings. The "Design Tools" program focuses on the market delivery of tools that will allow for full consideration of energy options in the design of our future buildings.
- OBT develops and promotes building enegy codes, appliance and equipment standards for residential and commercial buildings.

Through its Office of Federal Energy Management, DOE leads the Federal government's drive for increased energy efficiency and renewable energy utilization in its own facilities and vehicle fleets.

Contacts:

Arthur H. Rosenfeld, Science Advisor, Energy Efficiency
and Renewable Energy, DOE
Tel: (202) 586-6593, Fax: (202) 586-5145
E-mail:Arthur.Rosenfeld@hq.doe.gov

John Talbott
Tel: (202) 586-9455, Fax: (202)586-1628
E-mail: John.Talbott@hq.doe.gov

Department of Health and Human Services

National Institute for Occupational Safety and Health
Centers for Disease Control, Atlanta, GA 30333

Mission:

The National Institute for Occupational Safety and Health is the Federal Institute responsible for conducting work-related research and making recommendations to prevent illnesses and injuries. The Institute has a special focus on construction workers, with research addressing a wide range of construction-related hazards such as silica exposure, dermatologic conditions, ergonomics, falls, injuries, and exposure to lead.

Interstate highway repair, concrete drilling: Respirable quartz measured at 16 times the NIOSH recommended exposure limits.

Major Activities Contributing to the Construction and Building Program

- Conduct research and provide recommendations to employers, workers and agencies
- Evaluate potentially hazardous working conditions at the request of employers or employees
- Develop control technology solutions for problems of worker exposure
- Disseminate recommendations for preventing disease, injury, and disability
- Provide education and training for occupational safety and health professionals

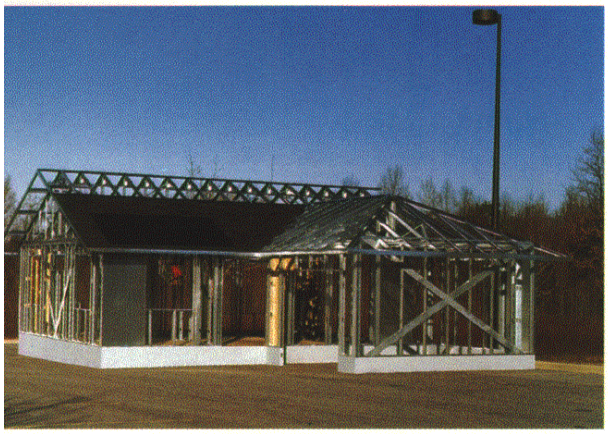
Contacts:

Jane A. Lipscomb, Senior Scientist, Office of the Director, NIOSH
Tel: (202) 205-7782, Fax: (202) 260-4464
E-mail: jal@oddc1.em.cdc.gov

Melvin Myers, Special Assistant to the Deputy Director, NIOSH
Tel: (404) 639-3345, Fax: (404) 639-2196
E-mail: mlm2@niood1.em.cdc.gov

Department of Housing and Urban Development

Policy Development and Research, Washington D.C. 20410



HUD demonstration/test home is part of AISI/NAHB/HUD cooperative agreement to research steel and develop prescriptive building methods. The purpose of the demonstration was to evaluate different attachment methods for different sheathing materials, and evaluate alternative details (e.g. headers, truss connections, etc.).

Mission:

The Office of the Assistant Secretary for Policy Development and Research is responsible to the Secretary of Housing and Urban Development for overall Departmental policy, program evaluation and research. The Division of Affordable Housing and Technology conducts research and analysis on the production and supply of housing and on the physical and technical aspects of community development. The Division addresses all physical, structural, developmental technology, regulatory, and related issues needed to support the Department's commitment to ensure decent, safe, and sanitary housing in a suitable living environment for all Americans.

Major Activities Contributing to the Construction and Building Program:

Expanding Housing Opportunities for Low and Moderate-Income Families

Research and policy analysis to expand affordable housing opportunities by reducing the initial and operating cost of housing and to expand the affordability of new and rehabilitated housing supplied by both the private and publicly-assisted market.

Empowering Communities

Technical, developmental and related regulatory research to assist in the physical redevelopment of communities.

Opening Housing Markets

Research to develop new legislative and regulatory tools to ensure that new development provides equitable access to jobs and housing for lower-income and minority families.

Meeting Key Administration Objectives

Research that permits the integration of other major social objectives such as environmental protection and hazard prevention into the programs of the Department and into housing production without sacrificing housing affordability and viable urban redevelopment.

Contact:

David Engel, Director, Affordable Housing Research and Technology Division,
Tel: (202) 708-4370, Fax: (202) 619-8360
E-mail: dengel@hud.gov

Department of Interior

Bureau of Mines
Washington D.C. 20241

Mission:

As the Nation's principle conservation agency, the Department of Interior has responsibility for most of our nationally-owned public lands and natural resources. The U.S. Bureau of Mines (USBM) is the primary organization within DoI dealing with issues related to building and construction. The USBM's Center for Materials Partnership conducts research leading to improved materials that offer resistance to corrosion, wear, and breakage and that can be substituted for materials that are hazardous to health and safety. Materials performance and service life prediction technologies provide the basis for economical and environmentally sound solutions to the Nation's materials needs. Materials used in the construction of infrastructure are an important component of the Center's research.

In support of the goals and efforts of the Subcommittee on Construction and Building, the U.S. Geological Survey (USGS) provides valuable input into the location and site selection of various construction and building projects, as well as into potential hazards and environmental impacts. Its mission is to provide scientific data concerning earthquakes, floods, erosion, ecosystem impacts, and energy and water availability.

The Yaquina Bay bridge (U.S. Highway 101) is currently being arc-sprayed with zinc for impressed-current cathodic protection of rebar. When completed, this treatment will greatly extend the service life of the bridge. The Bureau of Mines has installed corrosion experiments on the sheltered and exposed locations to assess corrosivity of microclimates and is investigating the effects of aging on bond strength of the arc-sprayed.

Major Activities Contributing to the Construction and Building Program:

- Provide expertise on environmentally safe and stable construction materials (e.g., Monticello roof restoration).
- Map corrosivity of coastal environments and effects of microclimates in Pacific Northwest.
- Develop atmospheric corrosion model for predicting performance of structural metals (e.g., National Acid Precipitation Assessment Program).
- Evaluate effects of environment on service life of construction materials an form anode and structures, including coastal bridges.
- Analyze construction material failures bridge in (e.g., phosphate slurry pipeline).
- Develop and refine impressed current zinc, cathodic protection systems for steel-reinforced concrete bridges.

Contacts:

Jeffrey A. Hawk, Performance of Materials, Center for Materials Partnerships, U.S. BoM
Tel: (503) 967-5900, Fax: (503) 967-5845

Gary Hill, Office of Program Planning and Coordination, U.S. Geological Survey
Tel: (703) 648-4451, Fax: (703) 648-5470

U.S. Department of Labor

Occupational Safety and Health Administration
Washington, D.C. 20210

Investigation of construction scaffold collapse.

Mission:

The mission of the Occupational Safety and Health Administration (OSHA) is to save lives, prevent injuries and protect the health of America's workers. To accomplish this, Federal and state governments must work in partnership with the more than 100 million working men and women and their six and a half million employers who are covered by the Occupational Safety and Health Act of 1970 (OSHA Act). OSHA and its state partners have approximately 2100 inspectors, plus complaint discrimination investigators, physicians, educators, standards writers, and other technical and support personnel spread over more than 200 offices throughout the country.

Because construction is such a hazardous occupation, the OSHA Office of Construction and Engineering was created in 1990 to improve health and safety in the construction industry. The office works with construction industry management and labor to implement proactive strategies for worker protection that make safety and health part of workplace culture.

Major Activities Contributing to the Construction and Building Program:

- Set standards to reflect construction industry safety performance and the need for worker protection.
- Conduct worksite inspections to enforce standards.
- Provide training to construction safety and health enforcement personnel to improve inspections. Training is also provided to industry personnel through agreements with local educational institutions, including community colleges.
- Investigate accidents to determine industry wide causative factors to be reduced or eliminated.
- Establish cooperative programs with companies to benchmark good safety practices and recognize those contractors who are role models for the industry.
- Coordinate Federal activity to assure a government leadership role in promoting health and safety programs through responsible construction project ownership.

Contact:

Bruce Swanson, Director of OSHA Office of Construction and Engineering

Tel: (202) 219-8644, Fax: (202) 219-6599

U.S. Environmental Protection Agency

Washington, D.C. 20460

Mission:

The mission of the U.S. Environmental Protection Agency (EPA) is to preserve and improve the quality of the environment, protect human health, and safeguard the productivity of natural resources on which all human activity depends. To achieve these goals, the Agency is committed to reduced risks to humans, the environmental, and natural resources using the best available science and innovative technologies.

While all aspects of EPA's activities can be linked to construction and building (C&B), major activities contributing to C&B goals include:

Major Activities Contributing to the Construction and Building Program:

- Provide leadership in the identification, characterization, and mitigation of indoor air pollutants. Develop technologies for the prevention of indoor air pollution.
- Promote energy conservation, efficient energy use through voluntary actions such as the energy star buildings, green lights and energy star computer programs.
- Promote sustainable development through the Green Buildings Initiative, the Environmental Technology Initiative, and community-based, in-place environmental management.
- Promote the safe and sustainable reuse of idled and underused industrial and commercial facilities through the Agency's "Brownfields Initiative."
- Promote efficiency and streamline environmental regulation through the Agency's Common Sense Initiative.
- Provide leadership in the Nation's environmental science, research, training and assessment.

Examination of polluted industrial site for possible reuse.

Contact:

Margaret Chu, Office of Research and Development, USEPA
Tel: (202) 260-5740, Fax: (202) 260-4524

Department of Transporation

Federal Highway Administration
McLean, VA 22101

Bridge column, Northridge earthquake, January 1994.

Mission:

The Department of Transportation (DOT) was established "to assure the coordinated, effective administration of the transportation programs of the Federal Government..." and to develop "national transportation policies and programs conducive to the provision of fast, safe, efficient, and convenient transportation at the lowest cost consistent therewith."

The Federal Highway Administration, Federal Railroad Administration, Federal Aviation Administration, Federal Transit Administration, and United States Coast Guard are the primary offices involved with programs related to the Nation's transportation infrastructure.

Major Activities Contributing to the Construction and Building Program:

- Research on High Performance Materials for Renewal Engineering will provide stronger, longer-lasting structures and facilities.
- Research on Diagnostics and Analysis will develop nondestructive testing and monitoring technology for futuristic transportation systems.
- Research on Automation for Renewal Engineering will supply robotics and site integration technologies that will reduce manpower requirements.
- Research on Reduction of Intermodal Hazards will help provide emergency response to transportation interruptions caused by earthquakes, floods, wind storms, etc., and restore lifelines.
- Research related to bridges, pavements, and geotechnology.

Contact:

Thomas J. Pasko, Director, Office of Advanced Research, FHWA
Tel: (703) 285-2035, Fax: (703) 285-2379

Department of Veterans Affairs

Office of Construction Management
Washington, D.C. 20420

Mission:

Veterans Affairs (VA) is dedicated to constructing quality facilities for serving veterans in medical centers, outpatient clinics, nursing homes, domiciliaries, regional office buildings, and cemeteries. VA's Office of Construction Management implements planning, design, construction, and real estate programs in support of the Department's missions, with a strong commitment to customer service. CM also promotes maximizing VA-owned assets through creative development initiatives.

VA Medical Center, Portland, Oregon.

Major Activities Contributing to the Construction and Building Program:

- Updating, consolidating, and automating Design and Construction Standards
- Developing criteria for operating in and responding to natural disasters
- Creating Design Guides to improve quality, control cost, and increase user satisfaction
- Managing traditional and alternate methods of design and construction, emphasizing the use of Design Programs to minimize the need for change
- Reviewing project designs for function, efficiency, and flexibility
- Creating and maintaining a Cost Data Base for budgeting

Contact:

Lloyd H. Siegel, Director, Facilities Quality Office
Tel: (202) 233-3663, Fax: (202) 233-2454
E-mail: siegel@dvacm.gov

General Services Administration

Public Buildings Service
Washington, D.C. 20405

The new United States Courthouse in Kansas City, Missouri, scheduled for completion in 1997, is one of the initial major government construction projects utilizing the metric measurement system. The design of the courtroom daylighting system offers an innovative design approach to the difficult task of introducing natural light into courtrooms.

Mission:

The General Services Administration (GSA) is the Federal business manager which responsibilities including space acquisition and management, retail and wholesale supply sales, fleet management, travel and transportation management, telecommunications and information management.

The Public Buildings Service (PBS) serves as the Federal Government's chief buildings planner, developer, owner, and real property asset manager. PBS managers over 8,000 buildings providing in excess of 267 million square feet.

Major Activities Contributing to the Construction and Building Program:

- The design and construction program in progress is estimated to be $8 billion, and more than $2 billion has been budgeted annually for new projects.
- Since 1973 energy consumption in PBS buildings has been reduced by more than 40 percent and eight percent from 1985 levels. Current energy usage is more than 40 percent below the Federal average.
- GSA participates with local utility companies' demand side management rebate programs. GSA now participates in energy rebate programs, retains the savings, and reuses the funding resources for additional program requirements.
- The PBS' Design Excellence Program has invigorated the design community to actively pursue GSA projects. GSA's new program stresses creativity, including the exploration of innovative use of technology. Emphasis is placed on the unique aspects of the particular project, design philosophy, possible approaches in carrying out the project, and project management.

The Health Care Financing Administration Headquarters located near Baltimore, MD, is scheduled for occupancy in late 1995. The facility is being developed by Boston Properties, Inc., with the GSA's Public Buildings Service serving as project management agency. The facility provides for innovative wetland conservation methods and energy management.

Contact:

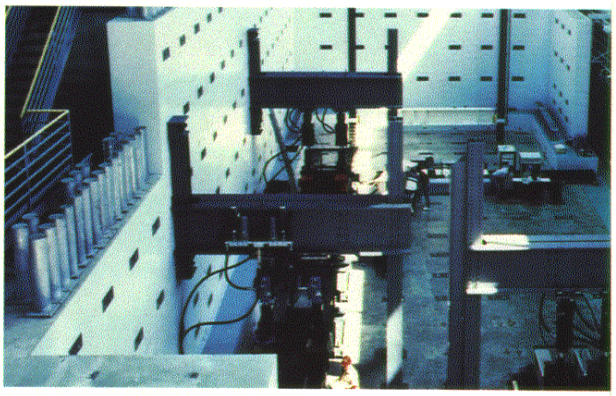
Wade Belcher, Public Buildings Service, GSA
Tel: (202) 501-1646, Fax: (202) 501-3393

National Science Foundation

Arlington, VA 22230

Mission:

The National Science Foundation (NSF) is created to promote and advance scientific and engineering progress in the United States. NSF funds research and education in most fields of science and engineering, through grants, contracts and cooperative agreements to colleges, universities, and other institutions. Civil infrastructure systems research (which includes the Construction and Building Program) is one of the Foundation-wide initiatives.



A Unique Multidirectional Experimental Laboratory in an NSF Engineering Research Center.

Major Activities Contributing to the Construction and Building Program:

- DETERIORATION SCIENCE examines how materials and structures break down and wear out, improving our understanding of deterioration and design, and how to build, and maintain structures that are more durable, safer, and more environmentally sound.
- ASSESSMENT TECHNOLOGIES determines durability, safety, and environmental conditions of structures and facilities. Research can lead to nondestructive evaluation techniques, improved sensor technologies, and self correcting materials.
- RENEWAL ENGINEERING extends and enhance the life of civil infrastructure systems and components that would otherwise continue to deteriorate.
- INSTITUTIONAL EFFECTIVENESS AND PRODUCTIVITY recognizes the importance of those factors affecting the decision processes underlying the provision and management of civil infrastructure on the economic and social productivity of society, leading to better decisions that maximize the impact of civil infrastructure investments on the productivity and on the economic and social well-being of the public.

Contact:

Ken P. Chong, Civil and Mechanical Systems Division, NSF
Tel: (703) 306-1361, Fax: (703) 306-0291
E-mail: kchong@nsf.gov

References

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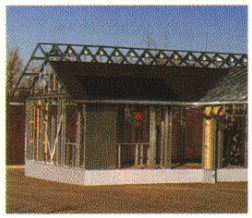

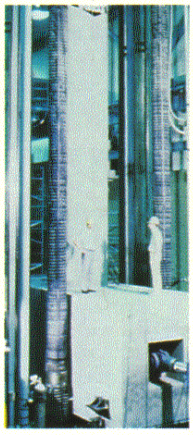

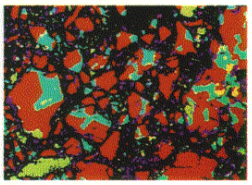

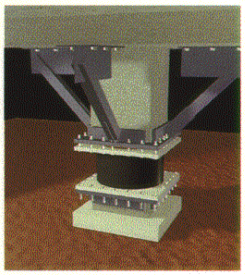

For additional information about the Construction and Building Subcommittee, please contact:
Dr. Andrew J. Fowell
Secretariat, Construction and Building Subcommittee
National Institute of Standards and Technology
Building 226, Room B-216
Gaithersburg, MD 20899
Tel: (301) 975-6865, Fax: (301) 975-4032
E-mail: afowell@enh.nist.gov