

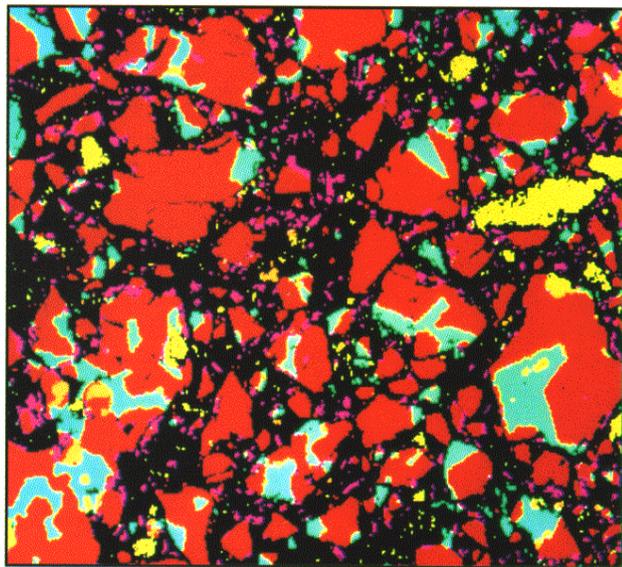
Government & Industry Working Together

by RICHARD N. WRIGHT

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Vision for 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 1993, new construction put in place amounted to \$470 billion, eight percent of the GDP, and provided employment for six million persons. New construction put in place in 1993 was 44 percent residential, 28 percent commercial, institutional and industrial, and 28 percent public works. When renovation is included, construction probably



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

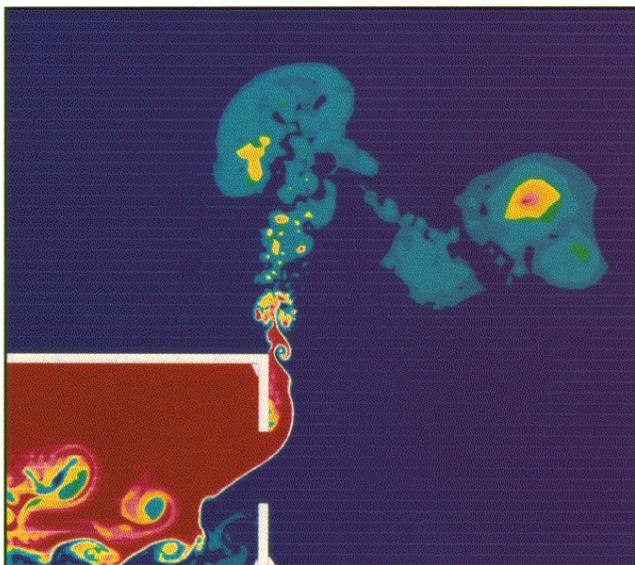
amounts to about \$800 billion annually, 13 percent of GDP and 10 million jobs. Constructed facilities shelter and support most human activities. Their quality affects the competitiveness of U.S. industry, the safety and quality of life of the people and environmental quality. For U.S. industries to compete internationally, their technologies must be superior and their production facilities must be more cost-effective than their competitors'. Moreover, the quality of construction strongly affects the wealth of the nation; over five-eighths of the nation's fixed reproducible wealth is invested in constructed facilities.

Construction includes the whole life of the project: initial planning and programming, design, manufacturing and site construction, occupancy and maintenance, condition assessment, retrofit and renovation or removal. Figure 1 shows the life cycle of constructed facilities and the industries involved in it. 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.

The *vision* for the construction and building industries is:

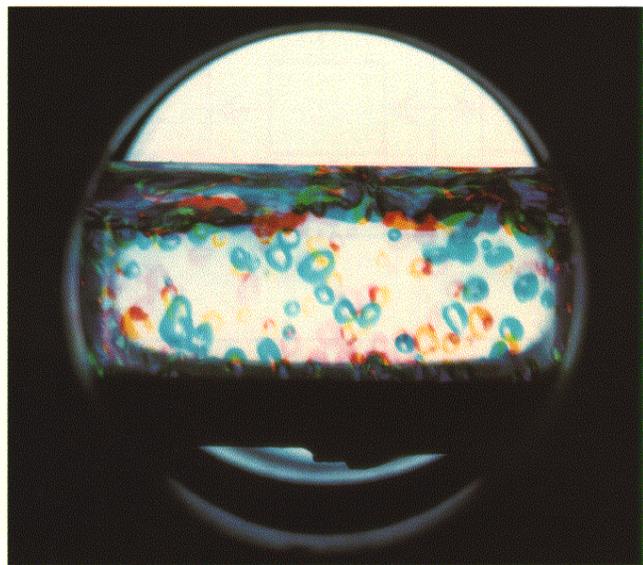
- High quality constructed facilities support the competitiveness of U.S. industry and everyone's quality of life.



Numerical techniques used to evaluate the flow of smoke and hot gases released by fires.

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.

The mission of C&B is to enhance the competitiveness of U.S. industry, public safety and environmental quality



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

- U.S. industry leads in quality and economy in the global market for construction products and services.
- The construction industry and constructed facilities are energy efficient, environmentally benign, safe and healthful and sustainable in use of resources.
- Natural and manmade hazards do not cause disasters.

National Science and Technology Council

The National Science and Technology Council (NSTC), a cabinet-level group chaired by the president, is charged with setting federal technology policy and coordinating R&D strategies across a broad cross-section of public and private interests. It has established nine research and development committees, including the Committee on

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 U.S. industrial competitiveness and create jobs.
- Make environmental protection and energy efficiency fully consistent with other business objectives.
- Balance funding for civilian and dual-use R&D with funding for purely military R&D.

Agencies participating in C&B are listed in Table 1. They include agencies with responsibilities for constructed facilities, for assistance or regulation for constructed facilities and construction, and also for research.

Goals for Construction Technologies

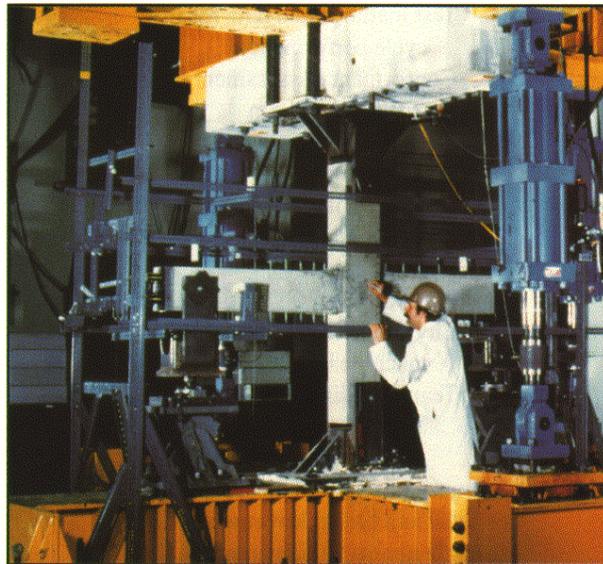
C&B has studied research priorities expressed by the construction industry in industry fora and in proposals for the Advanced Technology Program of the Department of Commerce. Two priority thrusts, better constructed facilities and health and safety of the construction workforce, were defined for focus of research, development and deployment (RD&D). 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 goals for the C&B Program are:

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

These goals will be achieved with

increased housing affordability, and where possible, with reduction in both initial and life cycle costs. The baseline for measuring progress against the goals will be today's business practices.

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. The response of



Innovative precast beam-column connections undergoing earthquake motion tests.

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." (See *CBR*, July-August 1994, Magnell, "A Building Block for America's Prosperity.") The white paper is an industry perspective of methods and means that, if jointly supported and implemented by the public and private sector, promises to transform the construction sector into the high technology/high skill sector the United States requires. Construction industry leaders strongly endorsed the goals established by C&B. The industry leaders urged

expanded dialogue and the immediate initiation of actions. C&B is involving all interested groups from industry and the public sector in developing the RD&D program to accomplish the goals.

RD&D Plan

Unfortunately, both private and public sectors are underinvesting in construction research. Total RD&D amounts to less than 0.5 percent of the annual expenditures for new construction, compared to an all-industry average of 3.8 percent. Therefore, private and public sectors are collaborating in defining and implementing the C&B program for RD&D to meet C&B goals and advance economic development.

The administration, in its budget guidance memorandum of May 6, 1994, has assigned priority for research and development to C&B for the FY 1996 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."

Program milestones for development and deployment of innovative technologies are chosen to achieve prompt benefits and accelerate progress toward the goals.

Research to improve construction technologies, education to bring the technologies to practice and the removal of non-technical barriers to implementation of advanced technologies are needed to achieve the C&B goals.



Seven areas of technology will be developed to achieve the goals:

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

3 High Performance Materials, Components, and Systems

- Advanced materials
- Advanced components
- Connections
- Building systems
- Mechanisms, models and data for life cycle performance
- Assessment and quality assurance technologies
- Renewal engineering
- Recycling and reuse
- Functional flexibility

4 Environmental Quality

- Energy conservation
- Indoor air quality
- Remediation of contaminated construction sites
- Sustainable development (ecological quality, conservation of raw 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

7 Human Factors

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

Improved technologies alone are not sufficient for improvement of the life cycle quality of constructed facilities and enhancement of the competitiveness of U.S. industry. The improved products and services must be successful in the marketplace and become the ruling technologies in construction practice. In a number of studies, industry has identified the following major non-technical barriers to beneficial innovations:

Lack of leadership. Policy makers in industry and government do not give priority to quality of constructed facilities consistent with their importance to the economy and quality of life. An important symptom of this lack of leadership is the overemphasis on first cost of construction with failure to recognize life cycle benefits possible from improved functionality, efficiency and durability.

TABLE 1

SUBCOMMITTEE ON CONSTRUCTION AND BUILDING

Federal Agencies Represented

- Department of Agriculture
- Department of Commerce
- Department of Defense
- Department of Energy
- Department of Health and Human Services
- Department of Housing and Urban Development
- Department of Interior
- Department of Labor
- Department of Transportation
- Department of Veterans Affairs
- Environmental Protection Agency
- General Services Administration
- National Aeronautics and Space Administration
- National Science Foundation

Life Cycle of Constructed Facilities

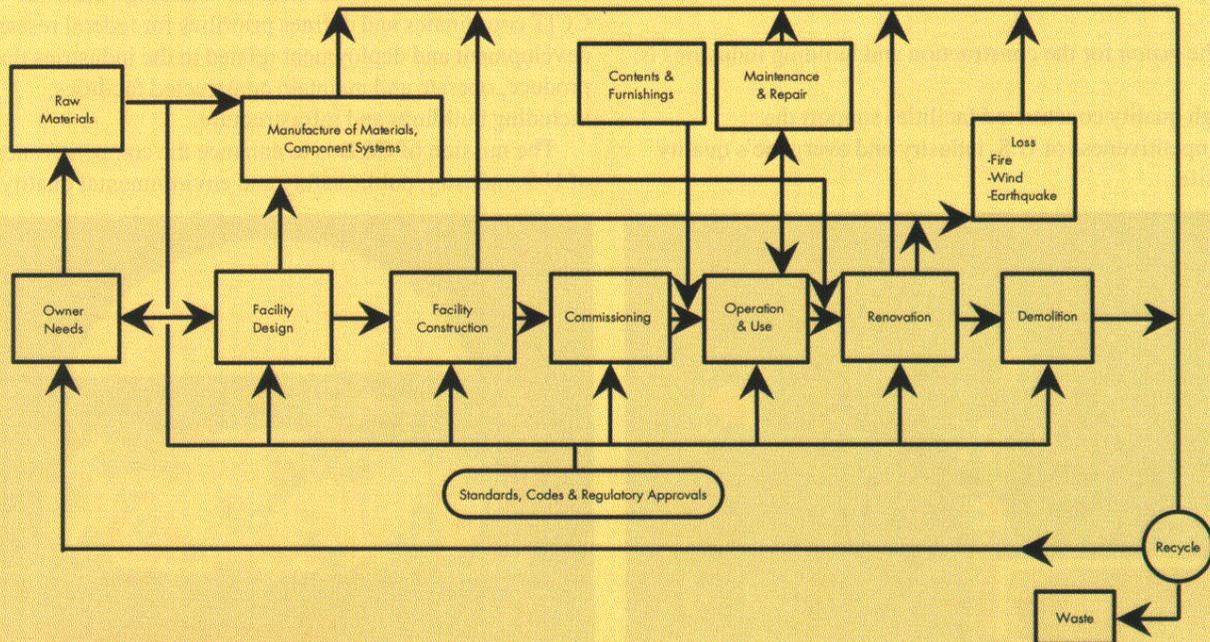


FIGURE 1

Regulatory barriers. Individual projects often are severely delayed by a large number of uncoordinated and sometimes conflicting regulatory requirements. Delay raises costs and leaves the need for the facility unfulfilled during the delay. The introduction of innovative products and services to the marketplace is made more expensive and delayed by the need to get approvals from many local jurisdictions.

Liability. Innovators and users of innovations face potentially large liability from real or imputed failures of products to perform over the service life as the customer or other injured party expected.

Adversarial relations in construction projects. Participants in each project for a constructed facility, such as owners, users, designers, manufacturers, constructors, and regulators, often take on adversarial

positions rather than partnership roles to achieve project objectives.

Financial disincentives for innovation. Industry and government have underinvested in construction R&D as compared to other industrial sectors. The large number of design and construction firms and the mobility of their work forces make trade secrets infeasible and patent enforcement difficult. Regulatory barriers noted above slow returns on investments in

"Federal construction and renovation projects provide an excellent showcase for innovations."

innovation. The overemphasis on first cost, noted above, is a barrier to products and services requiring increased first cost to achieve reduced life cycle cost. Education and training are required for successful use of an innovation; the innovator often is required to provide the education and training.

Education and training are required for implementers of the technologies (designers, manufacturers and fabricators, regulators, construction work force, operators and maintainers, and users). Educational materials and curricula will be required for each area of technology and each category of users. In some instances, research on educational methods may be needed for selected technologies and users.

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 innovations.

Executive Order 12902 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 technology and other renewable 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.



As the world's largest base isolation seismic retrofit project, the U.S. Court of Appeals in San Francisco posed special challenges. The use of innovative base isolation technology provided seismic safety at a cost less than alternative, traditional technologies.

Developing the Program with Industry

The subcommittee is working with the private sector to prepare a comprehensive, private and public plan to meet C&B goals. This work will improve the assessment of the adequacy of ongoing programs and provide a community-wide perspective of priorities for planned studies. All goals are important for the quality of constructed facilities supporting U.S. economic development and quality of life. To achieve each effectively, most nontechnical barriers must be removed, all deployment activities implemented and most technical objectives given high priority.

With the resources currently available, the following priorities are being considered for maximum progress toward C&B goals:

- Showcase and demonstration projects to speed application of available technologies and practices.
- Automation and information technologies to improve the quality of decisions in design and construction and to improve quality, and reduce time, costs and injuries in the construction process.
- Performance standards and conformance assessment procedures to facilitate the acceptance of beneficial, innovative products and services.
- Understanding of human factors affecting accidents of construction sites and in constructed facilities.
- Risk reduction technologies for extreme winds, earthquakes and fires. 



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