CONSTRUCTION INDUSTRY REPORT 1996

Participants:
CAPT Albert M. Calland, USN
Brigadier Sukhdev Plahe, Kenyan Army
LTC Joe R. Miller, USA
CDR Robert F. Dudolevitch, SC, USN
Lt Col John R. Edinger, USAF
LTC Gregory H. Evenstad, USA
Lt Col Tommy D. Hixon, USAF
CDR Mark T. Jaszkowski, USN
LTC Thomas G. Luebker, USA
Lt Col Douglas A. Nelson, USAF
Lt Col Gregory M. Postulka, USAF
Mrs. Barbara A. Scarlett, U.S. Information Agency
Mr. Stephen H. Shelton, Central Intelligence Agency
LTC Kimberley T. Smith, USA
LTC Thomas G. Wills, USA

Dr. Hugh Conway, Dept. of Labor, faculty
COL David Price, USAF, faculty

Places Visited (U.S.):
Georgia Institute of Technology
Associated General Contractors, Washington, DC
Kaiser Engineering, Boston, MA
Associated Sheet Metal Workers, Local 100, Suitland, MD
AGC, Seattle, WA
National Institute of Standards and Technology, Gaithersburg, MD
National Association of Home Builders, Washington, DC

Places Visited (International):
Vancouver, B. C., Canada
Santiago, Chile
Buenos Aires, Argentina
Sao Paulo, Brazil

ABSTRACT

This report examines the changes in the construction industry--such as design-build contract methodology and privatization of infrastructure--caused by the information systems revolution, economic globalization, and reduced government investments. It explores environmental issues and changing trade patterns in construction machinery and materials caused by the North American Free Trade Agreement. Lessons about terrorism and construction learned from the World Trade Center bombing are also highlighted.

INTRODUCTION

> *The aggregate value of the public works infrastructure in the United States is more than $2.7 trillion. The existence, upkeep and the modernization of this infrastructure are core to our economic competitiveness.*
>
> --Ronald H. Brown, U.S. Secretary of Commerce

The construction industry and its output are important factors in the nation's economic and political power equation. In fact, new construction starts are used to gauge the health of the entire economy. Currently construction spending totals over $850 billion annually. Shrinking government investment in infrastructure may have such a major effect on the industry that the United States will need to seek alternatives to government appropriations for the development and maintenance of infrastructure. Privatization and the concession process, widely used in many countries are possibilities.

In this report we examine the makeup and regulation of the construction industry, the changes that are affecting it, the effects of the globalization of the world economy, advances in networking and information processing, and technical developments in construction materials.

THE CONSTRUCTION INDUSTRY DEFINED

Constructed facilities shelter and support most human activities and directly contribute to quality of life. As such, construction, one of the

nation' s largest industries, is a critical asset for enhancing the international competitiveness of U.S. industry. In 1994, new construction and renovation combined amounted to about 13 percent of gross domestic product (GDP) and provided employment for over 6 million workers.

Industry Structure

Construction is a ubiquitous element in the U.S. economy, and its output supports all aspects of life. From houses to roads and water to electricity, construction sustains people and makes their world more comfortable. While the simplest to the most complex technological operations are found in the construction industry, its primary value comes from the *enhanced productivity* of the occupants, owners, and users of construction. The industry involves new construction activities plus maintenance and repair work; the life of a project starts with planning and design, progresses through construction to occupancy and maintenance, and ends with renovation or removal.

Construction is the product of a diverse group of subindustries that involve many individuals and organizations in a single project. The industry includes architects and engineers, contractors and subcontractors, skilled craftsmen and technical specialists, laborers, and equipment suppliers. There are almost 575,000 construction companies in the United States (168,164 general contractors, 37,348 heavy/highway contractors, and 367,762 special trade contractors). Companies range from very small (2-3 persons) to very large (thousands of employees); over 90 percent of construction companies have fewer than 10 employees. Firms generally operate locally or regionally; the largest are international. The largest contractors represent less than 10 percent of all contractor firms but account for about 30 percent of all earnings. Construction is regarded as an industry, but it is more accurately described as a multi-industry sector of the economy. The vision for U.S. construction is to remain competitive worldwide, to continue its lead in quality, and to build efficient and sustainable facilities by *giving customers what they want*

Management: Architects, Engineers, and Contractors

Managing construction projects is a complex endeavor.

Who runs construction projects? Project managers are generally contractors and construction engineers, but architects can also act in this capacity.

How are projects managed? Project management includes managing schedules, tracking goals and milestones, setting baselines, and measuring effectiveness. Projects must carefully adhere to design specifications so that the final product meets the stringent requirements of the building code and owner. Business school graduates rarely enter the construction field, so innovative management practices generally lag behind those being introduced in other industries.

Construction Occupations: The Trades and Skills

What do the workers do? The trades and skilled labor used in construction provide specific expertise for the project. The majority of workers are employed by special trade contractors, and the balance work directly for general or heavy/highway contractor companies. The trades are represented by such skills as *bricklayers, carpenters, electricians, heating and air conditioning specialists, painters, plumbers, roofers, sheet-metal workers, and wrecking and demolition workers.*

Types of Construction

Residential buildings. The residential sector, the largest component of the construction industry, accounted for about 43 percent of the value of construction put in place in 1995 (Table 1). It includes the categories of detached and attached single-family and multifamily homes and other residential buildings, including garages and motels. The largest element within residential construction is single-family detached houses, which account for 29 percent of the value of all construction. In 1995, 1.36 million new housing starts were recorded in the United States.

Private nonresidential buildings. This type of construction, which represents 31 percent of new construction spending, includes commercial buildings such as stores, shopping centers, restaurants, automobile service stations, industrial buildings, office buildings, manufacturing facilities, petroleum refineries, chemical process complexes, electric utilities, hospitals, medical care facilities and institutions, warehouses, and other,

less defined privately owned structures. The largest element of this type of construction is commercial buildings, representing over 9 percent of all construction. Construction of commercial buildings is currently continuing to increase gradually following depressed conditions caused by the overbuilding of office space in the 1980s.

Public works. Public works include construction facilities that support transportation, community life, and government systems, and accounted for about 27 percent of the value of construction put in place in 1995. These works include all types of roads, bridges, tunnels, and associated work as well as educational facilities, public buildings, water and sewer systems, railroads, subways, telecommunications operations, power and communication transmission lines, power plants, pipelines, and military facilities.

CURRENT CONDITIONS

Table 1 depicts both the trend and the outlook for each area of construction spending.

Shrinking *discretionary* budgets and the growing U.S. national debt have combined to reduce per capita funding to support the national infrastructure. Government at all levels is currently spending about $130 billion annually on infrastructure; however, government officials estimate that at least *another $40-50 billion is needed* to maintain the status quo.

Since 1970, private sector construction spending has trended upward in real terms while public sector spending has been virtually flat. Although the U.S. economy and population have grown, investment in infrastructure has lagged behind. Government spending has not maintained a long-range, investment orientation.

Table 1. Value of Construction Put in Place, 1990-99
Billions of 1992 dollars)

Type of Construction	1990 (actual)	1994 (actual)	1995 (estimated)	1999 (projected)
RESIDENTIAL	183.4	217.9	208.2	231.2
Single Family	109.0	126.8	140.3	140.4
Multifamily	19.3	12.8	16.3	15.4
Home Improvement	55.0	64.6	65.2	74.2
[1]	151.6	141.4	148.8	155.4
Commercial	34.3	29.1	32.1	32.2
Manufacturing	23.9	19.6	21.7	23.5
Office	28.8	15.8	17.4	17.6
Telecommunications	9.5	10.5	10.2	12.1
Other	54.9	63.7	64.8	70.1
PUBLIC WORKS	109.0	122.9	129.3	135.2
Highways	33.1	38.6	38.7	45.3
Educational	20.6	21.5	23.3	22.5
Other Public Buildings	17.4	17.8	19.0	20.5
Misc. Public Structures	8.6	11.6	12.8	13.3
Sewer Systems	9.5	10.7	11.0	11.8
Water Supply	4.7	5.6	6.4	6.5
Military	2.7	2.2	2.7	1.8
Other	12.4	15.1	15.6	16.6
TOTAL NEW	444.0	482.2	486.3	

[1]Includes railroads, electric utilities, gas and petroleum facilities, hospitals and institutions, and farm nonresidential construction.

In 1970, the public sector invested almost 2.8 percent of GDP in new construction. Comparable investment today is under 2.0 percent. The difference is a $44 billion annual shortfall.

By comparison, most other industrialized countries invest a higher percentage of GDP in public infrastructure than the United States does; in fact, Japan's investment was roughly triple that of the United States. Because the United States has not invested the requisite funds to sustain the current structure, the U.S. public infrastructure, a key ingredient in future productivity and competitiveness, has deteriorated. If this deterioration is left unchecked, it will adversely affect the national ability to mobilize rapidly in a crisis.

Government Regulation and Law

Federal law: OSHA and Davis-Bacon Act. Numerous government regulations that have a significant impact on the construction industry originate from federal, state, and local sources. Construction contractors often view these regulations as unnecessarily driving up the cost of business.

Several Occupational Safety and Health Administration (OSHA) regulations apply directly to the construction industry. Many contractors would like to see one of them, the General Duty Clause of the OSH Act, eliminated or scaled down, viewing it as an unreasonable and vague hazard abatement standard. Contractors also want OSHA to reward private industry for safety improvement efforts. Many believe that OSHA inspectors need additional training to understand the industry and want OSHA to use trained compliance officials to expose potential hazards in dangerous work environments and not simply issue citations following an accident.

The Davis-Bacon Act was passed in 1931 to ensure that federally funded construction projects paid the "prevailing wage." The effectiveness and cost of this legislation are difficult to evaluate, but the Congressional Budget Office estimates that at current rates of expenditure, the Davis-Bacon Act will add $3 billion to federal construction spending over a five-year period. In addition, 31 states have little Davis-Bacon laws.

Arguments for the repeal of Davis-Bacon include the following. First, the act is excessively complex and cumbersome, and causes a "deadweight loss" (i.e., a loss in economic activity due to administrative costs). In addition, it is logical to believe that the more something costs, the less one buys. Trends in infrastructure indicate that more investment is needed. And it seems preferable to let market conditions rather than the Department of Labor determine wages.

Arguments against repeal include maintaining the stability of the industry in local economies and preventing "traveling" contractors from underbidding projects based upon substandard wage scales.

State and local regulations. Building codes are established to provide minimum acceptable standards in the construction industry. Current standards regulating the home-building industry vary across three large regions of the country, but the U.S. government is promoting a national building code standard to give both domestic and international builders an opportunity to design and produce materials and goods meeting one national standard. Uniform plumbing standards have been established, mechanical standards are near completion, and building standards are slated for completion by 2000. Because lack of uniformity in building codes amounts to a nontariff trade barrier, the move toward uniformity will enhance access to the best materials.

Impact Fees

Land developers have recently been confronted with impact fees, which add significantly to their costs. According to the National Association of Home Builders, impact fees are defined as "charges . . . imposed at some point in the development process, calculated according to a formula and designed to provide infrastructure or services to the development or to ensure the development' s contribution to larger scale infrastructure expansions."

Political and legal constraints on traditional funding of infrastructure improvements through property taxes has transferred costs from property owners to land development firms. The fees are charged to support improvements in such infrastructure as roads, schools, sewers, and storm drainage. In California under Proposition 13, impact fees have driven up

the cost of a new home an average of $20,000 because of limitations placed on property taxes. The impact fees are essentially passed down from the land developer to the builder to the new home buyer. In many instances, impact fees slow growth, keep out low-income home buyers, and increase the value of older homes.

CHALLENGES

The Environmental Challenge

Every aspect of the construction industry has increasingly been affected by a wide range of environmental issues. For industry players from the individual homebuilder to the large construction firm designing and building huge commercial structures, the cost of discovering buried hazardous waste or disposing of large amounts of construction or demolition debris becomes higher every year.

Remediation. One of the biggest problems facing developers and builders alike is the burden of site remediation requirements. A well-executed site assessment can often detect contamination, and clean-up costs can be factored into the overall cost of construction. Unfortunately, the cost for the assessment can be quite high-often around $20,000.

The National Association of Home Builders cites costs varying from a low of $2,500 to a high of $8,500 to meet regulations on erosion control, storm water runoff, and tree preservation for each home. Extrapolating the per-house cost to larger developments yields a cost for large construction projects that can run into millions of dollars. In addition, the remediation process is often slow, expensive, and fraught with potential liabilities. Decontamination alone can be extremely expensive, and if hazardous wastes are involved, the costs soar even higher. Excavation disposal of petroleum-contaminated soil costs about $100 per ton and rises to $1,600 per ton for other hazardous waste products (landfill costs can add an additional $300 per ton). Large construction sites often contain thousands of tons of contaminated soil, leading to site remediation costs of millions of dollars. Major projects often experience unplanned remediation problems, resulting in schedule delays and cost overruns.

International opportunities in environmental areas. Tremendous opportunities exist for flexible and innovative construction firms to compete on the expanding world environmental market. In order to compete, U.S. firms must adapt to meet the needs of the international marketplace, but the potential payoff is worth the associated risk. Opportunities are expanding in developing nations in Asia and Latin America for pollution prevention, energy conservation, and waste treatment. The environmental market for five Latin American countries is valued at $2.45 billion a year and is projected to grow 25 percent per year, and the European market will have an environmental market valued at $63 billion per year by the end of this century. Worldwide environmental markets are expected to grow from their current $200-300-billion-per-year markets to $570 billion by 2010. Construction firms that adapt to local customer requirements and team with local firms will be key players in this expanding market.

The Global Challenge

The market. Construction accounts for about 10 percent or more of GDP in many countries. The value of total worldwide construction is approaching $5 trillion a year. The European Union accounts for $1 trillion; Japan, almost $800 billion; and the United States, over $500 billion in new construction. In 1993, U.S. construction contractors, who are strongly competitive in the international construction market, won about 40 percent of the $155 billion in contracts gained by the top 225 international contractors.

The construction business has become increasingly international during the past 20 years. Although only a small number of U.S. construction contractors are active internationally, they are among the most successful in the world. The 12 top U.S. contractors accounted for over 90 percent of the $63 billion U.S. international market in 1994. The U.S. strengths in this market are (1) large-scale design and (2) construction know-how developed from specialized technical engineering projects.

However, U.S. firms must compete in a global market where submitting the lowest bid is the critical determinant of who wins a contract. To be cost competitive, U.S. firms generally enter into partnerships with foreign firms and rely on foreign labor recruited by such firms. Contractors from

developing nations are generally more competitive on low-technology, labor-intensive projects because of their large supply of low-cost labor. Partnering with a U.S. company is attractive to foreign firms because they can obtain experience in advanced construction management techniques and high-technology construction and building systems.

International competition. Global population projections of a growing demand for public works and infrastructure, particularly energy, transportation, communications, and clean air and water facilities, will mean expanding markets for engineering-construction services and capital equipment. The best U.S. export opportunities will be in the fast-growing emerging markets, especially in Asia, where local companies will be unable to handle all the work.

International construction is a big industry in which fewer than half a dozen countries control more than 75 percent of the market. With the exception of the U.S. government, governments in all countries provide varying degrees of support to the construction industry. Export licensing makes it difficult for U.S. firms to ship technology or products to other countries (with the exception of Canada and Mexico), resulting in some lost opportunities.

Financing international projects. Under most systems, tax revenues and government borrowing are the dominant sources of infrastructure finance. Borrowing--whether from official or private sources--is backed by a government' s full faith and credit, and thus by its tax powers. Funds for infrastructure projects in developing countries account for the majority of international construction financing.

Increasingly important as a method of financing infrastructure projects is *privatization.* Since the mid-1980s, more than 70 major public purpose, privately financed infrastructure projects, valued at about $30 billion in 14 countries, have been developed. At least 100 other similarly financed projects, with capital costs totaling about $160 billion, are in some stage of development in 33 countries. The Chilean government, which is aggressive in its use of the free-market approach to infrastructure development, offers private developers the opportunity to build and operate roads and collect tolls for 20-year periods and then transfer the facility to the government in virtually new condition. The break-even

period is estimated at 8-10 years on most projects. At the end of the private operating period, the government has the option of operating the system itself or allowing bidders to operate it as a toll road.

This method, commonly referred to as *build-operate-transfer* (BOT), is an alternative method of privately financing a large infrastructure project that would otherwise be paid for with government appropriations. BOT has been utilized on the English Channel tunnel, Buenos Aires' Autopistas de Sol highway, the toll road from Sno Paulo to Rio de Janeiro, and Chile' s major north-south Route 5. The BOT method sends a strong international signal that the country encourages investment and development.

The United States has been reluctant to incorporate privatization; Virginia' s Dulles Airport toll road extension is one of the few projects to come to fruition. In the Seattle, Washington, area, voters rejected a bond measure to improve road and bridge improvements around Puget Sound because they were unwilling to pay the associated tolls. BOT offers the distinct advantage of ensuring that the operator pursues an optimum life-cycle costing solution rather than a low delivery-cost approach to construction projects. The result is an enduring, high-quality construction project serving the public' s best interest. Such efforts can only serve to enhance public confidence in the construction industry.

OUTLOOK

Trade in Construction Machinery and Materials

Machinery. With the globalization of the construction industry, the demand for U.S. products abroad is far greater today than it was a decade ago. The attractiveness of U.S. products is primarily the result of the depreciation of the dollar and lower tariffs. U.S. construction equipment and building materials are especially in demand in Germany to help rebuild the former East German states. We foresee high growth potential as Central Europe pursues infrastructure improvements and development.

The North American market has done well despite minimal growth over the past few years, in part as a result of the North American Free Trade Agreement (NAFTA) among the United States, Canada, and Mexico. The

advent of the world's largest free-trade zone, which encompasses 360 million people and a combined economy of $6 trillion, increased Deere and Company's exports to Mexico and Canada by 47 percent in two years. Construction machinery shipments to Canada and Mexico now account for 10 percent of the total U.S. construction machinery industry. NAFTA removed the tariffs of 15-20 percent on North American equipment sold in Mexico while maintaining duties against Japanese rival Komatsu Ltd. With the world's largest economy and its diversified and flexible manufacturing base, the United States is well positioned to benefit from free-trade pacts.

Nonwood products. U.S. exports and imports of nonwood products are directly tied to the strength (or weakness) of the domestic construction sector. To take advantage of the globalization of the building materials market, the United States and foreign countries are building plants and establishing joint ventures in other countries. In the United States, for example, 65 percent of the cement capacity and 45 percent of the clay brick capacity are foreign owned. Numerous U.S. building material companies are now operating in foreign countries, most prominently in Mexico and Canada, to meet demands there.

The value of U.S. building material exports of nonwood products rose 75 percent between 1989 and 1994 to a record $4.3 billion. The products most frequently exported were flat glass, builders' hardware, fabricated structural metals, plastic pipe and fittings, mineral wool, prefabricated metal buildings, crushed and broken stone, and metal doors and sashes.

The value of imports of nonwood materials rose over 200 percent between 1984 and 1994, totaling over $5.1 billion. The fastest-growing imports were asbestos, cement pipe, concrete block and brick, mineral wool, hard-surfaced floor coverings, crushed stone, and plastic construction materials.

Wood products. The United States remains the world's largest exporter and importer of solid wood construction material. Since 1992, imports have exceeded exports primarily as a result of a strong domestic construction market and reductions in logging in the Pacific Northwest. Exports, however, have remained fairly high because of market globalization and the increased demand for finished wood products.

The increase in U.S. exports of wood products of 160 percent between 1984 and 1994 is attributable primarily to trade with Mexico, to which U.S. solid wood exports increased over 500 percent in value over the past 10 years. Forty-four percent of all wood products exported by the United States go to Japan, however, which remains the leading buyer of U.S. solid wood construction materials. The U.S. wood exporters are targeting the Japanese construction sector because wood structures sustained minimal damage in the Kobe earthquake.

Exports of U.S. solid wood products have experienced steady growth over the past 10 years and are expected to continue to grow. Exports of construction materials experiencing the greatest growth include fabricated structural members (including laminated-veneer lumber and I-beams), hardwood flooring, hardboard, millwork (including moldings, doors, and windows), and hardwood veneer. However, softwood logs and lumber exported to Japan and Korea still make up 46 percent of the total U.S. solid wood products exports.

Imports of solid wood construction materials also increased steadily during the period 1984-94, reflecting a strong residential construction sector and the effects of reduced logging in the Pacific Northwest. Most of the steady growth is represented by imports of softwood lumber, which accounts for 59 percent of imports of wood construction materials. Other wood products that experienced strong import gains during the 1984-94 period were softwood logs, hardwood lumber, hardwood flooring, treated lumber, softwood veneer, and all reconstituted panel products.

Mechanical products. The United States has had a sizable trade surplus in heating, air conditioning, and refrigeration units since 1989. These products are attractive because they are state of the art but not expensive. By 1994, this surplus had grown to $1.8 billion as a result of the demand for high-quality U.S. products, the reduction or elimination of trade barriers, and better exchange rates.

Total U.S. exports in heating, air conditioning, and refrigeration units reached $4.2 billion in 1994, with Canada, Mexico, and South Korea accounting for 46 percent of those exports. Other major customers were Saudi Arabia, Japan, Hong Kong, Taiwan, and Thailand.

Composite materials and new techniques. Improved technology is the catalyst for change in the industry today. More durable composite materials, such as 3-M polyolefin fibers, increase concrete ductility, toughness, and crack control. DuPont produces composite materials and manufactures rugs from recycled plastic jugs. Hydraulic slip forms and pumps placing concrete from the bottom up are techniques that are speeding up the placement process.

Automation and software applications. Computers are revolutionizing design, management, and marketing in the construction industry. The 4-Dimensional Planner integrates a three-dimensional computer-aided design (CAD) model to produce updated project progress reports. 3-D programs enable buyers to tour a home or airport visually before purchasing one. The industry must embrace new advances in technology to remain competitive.

CAD is radically transforming construction. By encouraging all principals to be involved from the start of a project, new construction design software eliminates the constraints traditionally separating owners, architects, engineers, and contractors. Standardized programs today quickly produce project diagrams that are designed to be understood by a broad spectrum of professionals with different levels of technical expertise and generate building diagrams that can be quickly shared among the owner, engineer, and contractor. The resultant information sharing gives architects and engineers the input on which to base subsequent schematic modifications.

Information management enables companies everywhere to reduce middle management, outsource functions, reengineer processes, and reduce overhead. Networking is changing the face of the industry; new organizations are strategically and instantaneously linking and integrating key players such as designers, suppliers, subcontractors, and consultants into alliances that set the direction of the construction industry.

A striking example of automated data processing is Bechtel-Chile' s wide-area network. By tying together design elements for complex proposals in

a very short time, the network gives Bechtel a global competitive advantage and allows the company to aggressively pursue a multitude of projects.

Construction management and delivery systems. Construction management is now emerging as a principal delivery system. It provides the greatest degree of owner advocacy, promotes the team environment, stresses quality and safety, is cost effective, and is compatible with the design-build delivery system. Construction management is increasingly popular and lucrative; Parsons Brinckerhoff has increased its construction management revenue three times faster than its design revenue in recent years.

Improved information systems, new materials, flatter organizations, construction management, and design-build are the by-products of computer application to the construction industry. Traditionally, most construction contracts have delivered products through the design-bid-build system, but owners' demands for aggressive and efficient completion of fast-tracked projects have led to the emergence of a design-build delivery system. Twenty-five percent of all construction contracts in the United States in 1996 followed the design-build system, and the percentage is expected to grow over the next five years. Design-build with modifications will be the favorite delivery system for the industry in the future.

Design-build offers a single source of contractual responsibility to owners requiring fast-tracked project completion, thereby closing the communications gap between architects and contractors, eliminating time lost between design and actual construction, and minimizing the time lag between project conception and completion. Design-build enables the general contractor to focus on the owner's needs and then provide a customized, high-quality product on time to fit those needs. Although design-build may remove some of the checks and balances between the general contractor and the architect, it also eliminates many of the requests for information and communication problems typically encountered with design-bid-build. The integrity of the construction contractor is crucial to the success of the design-build partnership.

A *design-build and construction management mix* merges the speed of design-build with the checks and balances, teamwork, and advocacy of construction management. In this system, the owner, construction manager, architect/engineer, general contractor, subcontractors, and suppliers work as a team from the start to design a functional facility built with affordable and readily available materials. The contract approach of design-build is retained, but a separate construction manager is the owner's advocate in engineering and budget issues.

GOVERNMENT GOALS AND ROLE

Construction and Counterterrorism

In recent years the United States has become the victim of high-profile terrorism, namely, the bombings of the World Trade Center in New York City and the Alfred P. Murrah Federal Building in Oklahoma City. These attacks, coupled with increased incidents of terrorism in Israel, the United Kingdom, and Japan, have generated worldwide concern over the United States' s ability to protect facilities and their occupants. Vehicle bombs are the tactic of choice for terrorist organizations; therefore, protecting a building' s structural integrity from blast effects is an issue of great importance throughout the world.

In response to the threat of terrorism, President Clinton in June 1995, signed Presidential Decision Directive 39, which in part directs the Federal Emergency Management Agency (FEMA) to "ensure that the States' response plans are adequate and their capabilities are tested" with regard to acts "of terrorism directed against large populations in the United States, including terrorism involving weapons of mass destruction."

Despite this threat, in a recent survey of building design professionals, 68 percent acknowledged that they have not changed their design processes or considerations for public or government facilities in the wake of the bombings; the issue of awareness and concern is critical. Terrorism in the United States is no longer an abstract problem. The federal government, in cooperation with various architectural and engineering colleges and universities, professional architectural design and civil engineering

organizations, and various standards and codes agencies, needs to conduct a thorough and practical awareness program to ensure that, where prudent, blast-resistance considerations are incorporated into the design or retrofit of a particular facility or complex.

Recommendations for FEMA consideration:

1. Promote the education of design professionals and construction contractors on the range of measures and considerations that will protect both government and civilian buildings from terrorist activities.

2. Promote a partnership between building owners and the insurance industry that would develop insurance premium compensation packages for those structures and facilities that are hardened and prudently safeguarded from terrorist attack.

3. Promote the utilization of existing technical design manuals, threat-assessment methodologies, and computer-modeling programs developed for military applications with CD-ROM technology; publish and distribute consolidated collections of documents on this subject.

4. Promote the dissemination of these documents and assets to civilian building-design professionals and selected universities and colleges and their engineering and architectural design schools.

5. Promote the development of a comprehensive research and testing program of common building components and materials, assemblies, equipment, and associated designs applicable to the blast-resistant design of critical nonstructural building subsystems.

6. Promote and coordinate a plan for conducting national experimental and analytical studies on the blast resistance of structural subsystems that are typical of design and construction practices in government and civilian buildings.

7. In conjunction with the National Research Council, American Society of Civil Engineers, Association of General Contractors, American Institute of Architects, U.S. Army Corps of Engineers, Defense Nuclear Agency, Naval Facilities Engineering Command, National Institute of

Standards and Technology, State Department, General Services Administration, and other applicable agencies, develop and document the costs for reasonable, low-cost design standards and methods of incorporating blast-hardening and other blast-effect-mitigating features into existing buildings and future construction.

8. Develop as part of FEMA's Internet home page an electronic library of documents readily accessible or attainable by design professionals, security managers, and construction engineers to assist them in locating the myriad documents currently available on blast mitigation and physical security.

CONCLUSIONS

Without its extensive infrastructure of roads, tunnels, sewers, airports, harbors, schools, and reservoirs, the United States would not have developed the advanced economic system the nation thrives on. Whether supporting industrial might or developing minds in the education system, infrastructure assets are strategically vital to maintaining the United States's competitive edge in a global economy.

The construction industry's critical role in maintaining that edge is clear. All indicators point to an ever-increasing need to repair deteriorating transportation systems, to expand and refurbish public buildings, and to increase water and waste treatment capacity. Improvements to almost every category of infrastructure, from such public structures as schools, government buildings, and prisons to the vast transportation network of roads, bridges, tunnels, and airports, are essential.

Expansion requirements grossly exceed the projected availability of public funds. The $130 billion being spent annually on infrastructure is about $40-50 billion below what is required to maintain the status quo. Funding the investment in infrastructure improvements may be difficult, but the United States can ill afford to allow the infrastructure to deteriorate.

The construction industry takes major hits during every recession but continues to show phoenix-like powers of recovery. It supports private citizens, business, all levels of government, and the military infrastructure. It will continue to be called upon during national emergencies.

Construction in the next century will be a global, reputation-based industry composed of organizations that range from several giants offering diversified technical and professional services to many home-based craftsmen. Via computer technology and applications, networks will link subcontractors and suppliers with general contractors, design teams, and even owners. Interorganizational processes will be standard, and contract awards will be based on value. Success will come to international alliances among architects, engineers, and contractor firms in which all parties are committed to improving scheduling and quality and reducing costs. Owners will use construction managers to ensure that the team' s goals match the owner' s. Design-build combined with construction management will be the primary contracting delivery system. Construction design and materials will continue to evolve and improve in response to terrorist threats; buildings will be constructed to better withstand terrorist attacks, and security improvements will reduce the threat of penetration.

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