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AGING INFRASTRUCTURE

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In this issue of *The CIP Report,* we examine aging infrastructure and its impact on the security of our nation. The articles we feature this month analyze aging infrastructure issues within different sectors as well as overall areas that require attention.

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The first article provides an overview of the American Society of Civil Engineers' (ASCE) 2009 *Report Card for America's Infrastructure*. The second article comes from the American Association of State Highway and Transportation Officials (AASHTO) and provides an overview of their goals and current work. The third article focuses on a presentation from the Workshop on Aging Infrastructure held July 2009 at Columbia University.

We also feature a contribution from ASME Innovative Technologies Institute, LLC (ASME-ITI) on optimizing infrastructure investments. The next article discusses physical exams of aging buildings and the various issues that are involved with these buildings. Water infrastructure is another area featured in an article from the Water Environment Federation. The following article looks at the transportation sector, specifically the Washington Metropolitan Area Transit Authority (WMATA), and analyzes its critical funding needs. An article from New York University discusses infrastructure security and natural hazards. Lastly, *Legal Insights* discusses the Transportation Appropriations Act.

We hope you find this issue of *The CIP Report* informative and helpful. Thank you for your feedback and support.

Mick Kicklighter
Director, CIP
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America's Infrastructure

by Andrew W. Herrmann, PE, F.ASCE
ASCE 2010 Treasurer and Chair 2009 Report Card for America's Infrastructure

Our nation's infrastructure is plagued by aging systems and inadequate capacity. Earlier this year, the American Society of Civil Engineers (ASCE) released its 2009 *Report Card for America's Infrastructure*. The report found that the country's infrastructure rated a disappointing cumulative grade of "D," the same grade in the previous report card in 2005. This reflects little or no progress maintaining, repairing, and modernizing the nation's infrastructure over the last four years. In fact, while only one grade improved, that of the energy category, grades in three categories, aviation, roads, and transit, dropped.

Massive investment is needed at all levels of government to raise the infrastructure grades to an acceptable level. The Report Card shows a staggering deficit between the actual and needed investment levels. ASCE estimates the need for investment to be $2.2 trillion over the next five years, an increase of more than half a trillion dollars since 2005. Current spending projections are only $1.1 trillion over that same period, equal to just 50 percent of actual need.

Problems

While it is easy to become caught-up in large budget numbers and nationwide concerns, the problems of America's infrastructure affect the everyday lives of Americans in a concrete way. For example, transportation systems across the U.S. are suffering the effects of age and overuse. Failure to invest in an already over-stressed transportation infrastructure is having a tangible impact on Americans' way of life, including longer commute times, greater wear on vehicles, and increased safety concerns. Decaying transportation systems also have a significant impact on U.S. businesses, by delaying freight delivery, creating unpredictability in supply chains, and increasing shipping costs, which increases consumer costs and diminishes competitiveness.

One-third of America's major roads, a category which received a "D-" in the Report Card, are in poor or mediocre condition, and forty-five percent of major urban highways are congested. Americans are spending 4.2 billion hours a year stuck in traffic at a cost to the economy of $78 billion, or $710 per motorist. Congestion has become a critical challenge for the nation's highway systems, with wasted fuel climbing from 1.7 billion gallons in 1995 to 2.9 billion gallons in 2005.[1] Additionally, more than 26 percent of the nation's bridges are either structurally deficient or functionally obsolete, with the number of deficient bridges in urban areas rising.[2] With bridges remaining a "C" in the Report Card, an annual investment of $17 billion is needed to substantially improve conditions, compared to the $10.5 billion that is currently being spent. Together, roads and bridges need an investment of $930 billion over the next five years; however, there is a projected deficit of $594 billion.

In addition to roads and bridges, Americans increasingly depend on public transit systems for their transportation needs. Transit use increased 25 percent between 1995 and 2005, more than any other mode of transportation, but unfortunately, U.S. transit infrastructure only received a grade of "D" in the Report Card. Nearly half of American households do not

(Continued on Page 3)

[1] Texas Transportation Institute, *The 2007 Urban Mobility Report*.

[2] A structurally deficient bridge may be closed or restrict traffic in accordance with weight limits because of limited structural capacity. These bridges are not necessarily unsafe, but must post limits for speed and weight. A functionally obsolete bridge has older design feature and geometrics, and though also not necessarily unsafe, cannot accommodate current traffic volumes, vehicle sizes and weights.

ASCE *(Cont. from 2)*

have access to bus or rail transit, and only 25 percent have what they consider a "good option." The Federal Transit Administration estimates that $21.6 billion is needed annually to improve the system to good conditions. In 2008, federal contributions totaled $9.8 billion.

Another mode of transportation becoming increasingly popular, yet still suffering from condition and capacity issues, is the nation's rail system, which received a "C-" in this year's Report Card. As fuel efficiency becomes more important, the rail system will continue to be a viable option for both cargo and passenger travel. A freight train is three times as fuel efficient as a truck, and traveling by passenger rail uses 20 percent less energy per mile than traveling by car. To accommodate the increase in demand, an investment of more than $200 billion is needed through 2035.

Surface transportation is not the only form of transportation that is in need of attention. Both inland waterways and airports received poor grades in the Report Card, "D-" and "D," respectively. Airports continue to grapple with outdated systems that cause delays and waste money in fuel and time. In 2007, airlines incurred the second-worst on-time arrival record in history, with only 73 percent of flights arriving on time. A funding shortfall of more than $40 billion over the next five years will only serve to intensify the problem. Meanwhile, the nation's inland waterways also need major repair and updating. Of the 257 locks still in use on these waterways, 30 were built in the 1800s and another 92 are more than 60 years old, well past their design life of 50 years. The cost to replace the present system is estimated to be more than $125 billion.

While transportation may provide some of the most visible evidence of aging infrastructure, the management of water and environmental systems can also have a major effect on Americans' quality of life. Leaking pipes lose an estimated 7 billion gallons of clean drinking water every day. Aging facilities and an annual shortfall of $11 billion in spending earned the U.S. drinking water systems a grade of "D-." Similarly, wastewater treatment in the United States also received a grade of "D-." The physical condition of many of the nation's 16,000 wastewater treatment systems is poor due to a lack of investment in plants, equipment, and other capital improvements. Sanitary sewer overflows, caused by blocked or broken pipes, result in the release of as much as 10 billion gallons of raw sewage yearly, according to the EPA.[3] The U.S. drinking water and wastewater systems need a combined investment of $255 billion, but the projected spending is only $140 billion. If the nation fails to meet these needs, it risks reversing public health, environmental, and economic gains of the past three decades.

In addition to the problems with the nation's water systems, both dams and levees faired poorly in the Report Card with a "D" and "D-," respectively. Many dams have been determined to be deficient as a result of aging, deterioration, and lack of maintenance. There are more than 85,000 dams in the United States, and the average age is 51 years. The number of dams determined to be deficient has risen to more than 4,000 — including 1,819 that are classified as high hazard potential dams.[4] Over the past six years, for every deficient, high hazard potential dam repaired, nearly two more were declared deficient. Levees, which have received a great deal of attention in the last few years, received a nearly failing grade due to a lack of information about their reliability, their impact on life and safety issues, and the significant consequences of failure. More than 85 percent of the nation's estimated 100,000 miles of levees are locally owned and maintained. Rough estimates put the repair and rehabilitation cost at more than $100 billion.

While solid waste management received the Report Card's highest grade of "C+," it still faces numerous challenges. This grade is due in large part to the fact that more than a third of solid waste was

(Continued on Page 4)

[3] U.S. Environmental Protection Agency, *Clean Watersheds Needs Survey 2000 Report to Congress*, January 2004, www.epa.gov/owm/mtb/cwns/2000rtc/toc.htm.

[4] Association of State Dam Safety Officials, *Statistics on Dams and State Safety Regulation* (2007).

ASCE *(Cont. from 3)*

recycled or recovered, an increase of seven percent since 2000. However, per capita waste generation has remained generally constant over the last two decades, and the increasing volume of electronic waste creates potentially high levels of hazardous materials and heavy metals in the nation's landfills. Additionally, despite its potential for creating jobs and production revenue, brownfields redevelopment is underfunded — which is why hazardous waste received a "D." Federal funding for reclaiming the nation's worst toxic sites has declined to its lowest level in twenty years and 188 cities across the U.S. have brownfields[5] sites awaiting cleanup.

Solutions

The nation's infrastructure faces real problems that threaten our way of life if they are not addressed. These problems are solvable if we have the needed vision and leadership. Raising the grades on our infrastructure will require that we seek and adopt a wide range of structural and non-structural solutions, including technical advances, funding and regulatory changes, and changes in public behavior and support. In addition to the grades in the Report Card, ASCE also offers five key solutions to begin solving America's infrastructure crisis.

Increase Federal leadership in infrastructure.

During the 20th century, the federal government led the way in building our nation's greatest infrastructure systems. The New Deal programs, the Interstate Highway System, and the Clean Water Act are a few examples of that strong leadership. Unfortunately, federal leadership has since decreased, and the condition of the nation's infrastructure has suffered. America's infrastructure needs bold leadership and a compelling national vision, and that strong national vision must originate with strong federal leadership and be shared by all levels of government and the private sector.

Promote sustainability and resilience.

Infrastructure systems must be designed to protect the natural environment and withstand both natural and man-made hazards, using sustainable practices, to ensure that future generations can use and enjoy what is built today, as we have benefitted from past generations. Sustainability and resiliency must be an integral part of improving the nation's infrastructure, and both structural and non-structural methods must be applied to meet challenges. Additionally, research and development should be funded at the federal level to develop new, more efficient methods and materials for building and maintaining the nation's infrastructure.

Develop federal, regional, and state infrastructure plans.

Infrastructure investment at all levels must be prioritized and executed according to well conceived plans that both complement the national vision and focus on system-wide outputs. Goals of the plans should center on freight and passenger mobility, intermodality, water use, environmental stewardship, and encouraging resiliency and sustainability. These plans must reflect a better defined set of federal, state, local, and private sector roles and responsibilities, and instill better discipline for setting priorities and focusing funding to solve the most pressing problems. Additionally, they should complement broad national goals of economic growth and leadership, resource conservation, energy independence, and environmental stewardship.

Address life-cycle costs and ongoing maintenance.

As infrastructure is built or rehabilitated, life-cycle cost analysis should be performed for all systems to account for not only initial construction, but also operation, maintenance, environmental, safety, and other costs reasonably anticipated during the life of the project, such as recovery after disruption from natural or man-made hazards. Additionally, owners should be required to perform ongoing evaluations and maintenance to keep the system functioning at a safe and satisfactory level.

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[5] Brownfields sites are former industrial and commercial sites potentially containing hazardous waste.

American Association of State Highway and Transportation Officials (AASHTO): Working Toward Reviving our Aging Bridges and Structures

by Kelley Rehm, P.E.
Consultant for the AASHTO Bridges and Structures Program

AASHTO Overview

The American Association of State Highway and Transportation Officials (AASHTO) is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all five transportation modes: air, highways, public transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system.

Membership in AASHTO is on an agency basis. All State Departments of Transportation (DOT) are active members, and several sub-state and federal transportation agencies in the United States, as well as many transportation agencies in other countries, belong to the Association as associate members. Membership is not extended to individuals or private sector entities.

Much of AASHTO's work is performed by committees comprised of member department personnel who serve voluntarily. The Association provides a forum for consideration of transportation issues and is frequently called upon by Congress to conduct surveys, provide data, and testify on transportation legislation. Through AASHTO's policy development activities, member departments often address federal programs and provide guidance.

For 2009 AASHTO has developed a Strategic Plan to include the following goals:

Goal 1: Re-establish transportation as a national priority.
Goal 2: Advocate and communicate to achieve AASHTO's goals.
Goal 3: Provide world class technical services.
Goal 4: Assist State DOTs with leadership and performance.

Vision: The American Association of State Highway and Transportation Officials is the voice for transportation and catalyst for organizational and technical excellence.

Mission: The American Association of State Highway and Transportation Officials advocates transportation-related policies and provides technical services to support states in their efforts to efficiently and safely move people and goods.

The Highway Subcommittee on Bridges and Structures (SCOBS), in conjunction with many other committees and subcommittees, is working hard to meet Goal 3. The primary intent of this goal is to ensure the continuation of AASHTO's world leadership role in the development of transportation standards and other technical services. This goal will focus on increasing the number of beneficiaries, ensuring continued state DOT participation in critical technical activities, expanding training opportunities for transportation agency professionals, and developing centers of excellence in safety, operations, finance, and freight transportation. As part of this goal, the SCOBS, along with the Subcommittee on Maintenance, is striving to provide technical expertise, research, and technical services in the area of PRESERVATION for our aging bridges and highway structures.

AASHTO Subcommittee on Bridges and Structures (SCOBS): Working Toward Preserving Our Aging Infrastructure

The AASHTO SCOBS is one of the many groups within AASHTO

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AASHTO *(Cont. from 5)*

making significant efforts to preserve our country's aging infrastructure, in particular, its bridges and structures. In 2006, a new technical committee, a subgroup of SCOBS, was formed with the designation of Bridge Preservation. This group works closely with the AASHTO Subcommittee on Maintenance in order to promote needed research and technical activities in the area of preservation of the nation's bridges. More information on this technical committee, as well as the other 19 technical committees under SCOBS, can be found at http://bridges.transportation.org.

After the tragic collapse of the I-35W Bridge in Minneapolis in 2006, much attention was focused on the condition of the nation's bridges and structures. As a result of the National Transportation Safety Board's (NTSB) investigation, several recommendations on the preservation of bridges were presented to AASHTO. Out of the six recommendations provided to AASHTO by NTSB, three of them dealt with inspection and preservation of existing bridges. SCOBS worked quickly to meet the recommendations of NTSB. At the annual meeting of SCOBS in July 2009, the Subcommittee approved amendments to the AASHTO *Manual for Bridge Evaluation* (MBE) and the AASHTO Guide to *Commonly Recognized Structural Elements* (CoRE) document that provided for more in-depth information on how to inspect and load rate gusset plates and connections. AASHTO also supports a Federal Highway Administration / National Cooperative Highway Research Program study that will provide even more in-depth understanding of gusset plates and their modes of deterioration.

SCOBS has also recently formed several working groups that will provide valuable information in the areas of bridge inspection and preservation. One of these working groups is preparing a proposal for providing for Element Level inspection within the Federal National Bridge Inspection System (NBIS). The current system is dependent on overall structure ratings such as Sufficiency Ratings and "Structurally Deficient" labels, which, as we have seen in the media, were never intended to be used by the general public and do not reflect the true condition or safety of a bridge. By incorporating element level inspection ratings, the system will reflect a clearer understanding of the condition and health of a bridge. The second working group recently has been assigned to look closely at truck size and weight issues to see how the changes in that industry are affecting highway structures.

AASHTO has also developed a technical service program centered on Transportation System Preservation. AASHTO has contracted with the National Center for Pavement Preservation (NCPP) to host the Transportation System Preservation Technical Services Program (TSP•2). The goals of the TSP•2 are to:

1. Provide a clearinghouse for comprehensive, up-to-date information on effective preservation technologies that enhance pavement and bridge performance and extend their useful service life;

2. Develop and administer a system preservation "Help Desk" to afford State highway agencies with a one-stop source for technical, training, and outreach services; and

3. Offer State highway agencies the means to exchange ideas, information, and best practices with one another.

A website serves as the focal point for TSP•2 information and activities. The website can be accessed at: http://www.tsp2.org. Access to the website is open to all State highway transportation personnel and other interested pavement and bridge practitioners. The TSP•2 website has several features designed to facilitate the exchange of preservation information. These include:

1. The TSP Preservation Research Roadmap;
2. A Bulletin Board and System (BBS), containing a wide range of preservation

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Intelligent Infrastructure: Securing Regional Sustainability Presented at the Department of Homeland Security's "Workshop on Aging Infrastructure" at Columbia University, July 2009

by James Carlini*
President, Carlini & Associates, Inc.

If a city and/or region want 21st century viability, new intelligent infrastructure and amenities are key to their future economic development and regional sustainability. There needs to be a solid "Platform for Commerce" to build upon. That platform provides broadband connectivity (multiple gigabit networks) and redundant power and distribution facilities to a multi-layer infrastructure which includes the more traditionally-defined layers like ports, roads, bridges, and railroads.

Why has this become so important? The three most important words in real estate have changed from "*Location, Location, Location*" to "*Location, Location, Connectivity*" in the last couple of years. Any planned commercial development must reflect this significant change in order to be competitive to attract first-rate tenants.

With Intelligent Business Campuses (IBCs) and Intelligent Industrial Parks (IIPs) under various stages of development and completion around the world, the way corporations and local government agencies view regional sustainability, job development, and retention as well as urban economic development, has changed. Those that do not see this fundamental shift will be left out of any real economic development and regional sustainability.

New design concepts need to be understood and applied to next generation industrial campuses as sophisticated tenants demand security, reliability, and redundancy to compete in the global marketplace of the 21st Century. As acknowledged in an earlier white paper, *Intelligent Business Campuses: Keys to Future Economic Development:*

Power and network planning have shifted to upfront Master Planning from being an afterthought after the corporate tenant moves in.

The primary challenge facing today's local and regional governments is to create a solid "platform for commerce" that companies and other organizations can build upon to expand their regional as well as global trade. This is a necessary foundation for any region and it insures the economic security of that region.

Traditional economic development in many American municipalities consisted of selecting a site, creating a TIF (Tax Increment Financing) district around it and then with a lot of fanfare, proclaiming that this area was "great for business and commerce". Hopefully, it would attract a higher caliber of development. Some TIF districts have been successful, but many recently created ones are still standing vacant as the initial hype has worn off, but no major developments have moved in.

Proclaiming a place is "great for business and commerce" is not the same as preparing it for business and commerce. Corporate site selection committees are getting more discerning. Whether they are looking at a self-contained campus or a site within a shared campus environment, corporations are getting more selective in what properties they will consider to build facilities on. These properties have to show pre-built infrastructure in order to gain in the rankings of possible sites to be included in a short list.

Infrastructure: 3,000 Years in the Making

A clear definition of what infrastructure consists of and what it supports is critical for today's strategic decision-making on tomorrow's long-term projects and economic development initiatives. Having a framework to refer to can only help structure discussions as well as clarify where security, power, and network connectivity priorities have to be focused.

Throughout the ages, trade routes were considered important to the regional sustainability of every civilization. From the Phoenicians

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Sustainability *(Cont. from 7)*

and Romans to the Chinese, to the more historically recent Europeans and the United States, trading goods and services was paramount to civilizations to thrive and survive. To put it in a historical perspective, Chart 1 (below) gives an overall view of the expansion of commerce and the seven layers of critical infrastructure that supported its growth and expansion throughout the last three thousand years.

To many people involved in infrastructure improvements, they fail to see the total picture or in this case, the total framework that provides for the platform for commerce. Each layer has significance and must be addressed when building new facilities as well as trying to retrofit existing facilities.

Critical Trade Routes Have Become Electronic

Throughout the last three Millennia, trade routes have been important to the expansion of trade, culture, and commerce. Now, those trade routes are also electronic and the need to include this layer is critical as it relates to global commerce and the digital world that we have created.

These electronic trade routes must have security woven into the fabric of this layer as billions, if not trillions, of dollars of securities and trade pass through it on a weekly basis. Many new and existing industrial parks have substandard protection when it comes to wireless networks and other communication media that can be compromised.

Just as expanding trade routes in the past meant overcoming natural obstacles, including water, land, and air, in our digital world — spam, viruses, and other electronic security impediments must be dealt with and defeated.

Most people have not yet equated broadband connectivity (network infrastructure) with the rest of the layers of critical infrastructure that have been recognized throughout centuries as needed for transportation and global commerce. The need to understand

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CHART 1: Critical Infrastructure Framework That Provides the "Platform for Commerce"

LAYER	LEVEL	DOMINANT INITIAL DRIVER OF IMPLEMENTATION IMPORTANCE
SPACE (FUTURE) (INTERPLANETARY)	(8)	JUST BEGINNING TO BE BUILT (|Space shuttles, space station, satellite networks| Future – mid-21st Century, 22nd Century? US, RUSSIA, JAPAN, CHINA?)
BROADBAND CONNECTIVITY NETWORK	7	CHINA, JAPAN, KOREA, NETHERLANDS (beginning 21st Century)
AIRPORTS	6	UNITED STATES, EUROPE (mid-20th Century)
POWER (GRIDS, NUCLEAR POWER)	5	UNITED STATES (beginning/ mid 20th Century)
TELEPHONE NETWORK (VOICE ONLY)	4	UNITED STATES (beginning/mid 20th Century)
RAILROADS	3	UNITED STATES (mid-1800s)
ROADS/BRIDGES	2	ROMAN EMPIRE (500BC- 476AD)
PORTS/ DOCKS/ WATER	1	PHOENICIANS (1200BC-900BC)

Source: JAMES CARLINI,

Sustainability *(Cont. from 8)*

how to maximize those electronic trade routes is critical to maximizing the economic viability of a region.

The Transportation of Information

The importance of the Internet is finally being recognized in this century by those that should have been rebuilding their copper "roadbed" of telephone network that they built in the United States decades ago. Just like single-lane dirt roads which evolved into the multi-lane superhighways of today, the single-function copper-based voice network has to be updated to a multi-channel, multi-gigabit network that can handle the explosive growth of video and other convergent applications. Just as you cannot drive fast on a dirt road, you cannot transport information fast on copper. At this point, copper should be replaced not only from a speed standpoint, but from an infrastructure security standpoint as well.

There have been several plans proposed by various groups to develop a national broadband strategy as well as its implementation. The major flaws in these plans are that their target speed is too low and they rely upon the embedded copper infrastructure. They are not setting the bar high enough within the planning stage. 100 Megabits per second is not what we should be aiming for as a standard speed.

Many people do not know how to convey speed of transmission or what it relates to in everyday life. This is part of the problem in trying to sell the importance of upgrading networks to a much faster broadband connectivity where new applications would be created. The chart at the bottom of this page is the "Speed Chart" which was developed to use as a tool to provide an example of the significant differences in delivery time of a 90-minute full motion video based on what type of network circuit was being used.

The Importance of Having a Solid Infrastructure

Regional sustainability will be based on having a solid "platform for commerce" which includes all the levels outlined in Chart 1. This is a global phenomenon as other countries have also implemented projects that adhere to this concept.

Unfortunately, many traditional organizations who are supposedly "experts" in infrastructure do not even include broadband connectivity as a layer within the total framework. Before any great action plan can be implemented, everyone has to be on the same page as understanding what makes up the infrastructure. We cannot have a 1950s approach on understanding, let alone creating and implementing, a strategy for re-building infrastructure.

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Speed Chart

Speed of Transmission
Downloading a 90-minute movie (1 gigabyte*)

Speed of Circuit (type)	Time Elapsed (rounded)
56 Kbps (dial-up)	426 hours (~17.7 days)
1.5 Mbps (DSL, cable, T-1)	15.91 hours
10 Mbps (wireless)	2.39 hours
1 Gbps (fiber to the curb)	8.59 seconds
10 Gbps (fiber to the house)	0.86 second

Source: James Carlini

*Gigabyte: a unit of information equal to 1 billon (actually 1,073,741,824) bytes (or 8,589,934,592 bits) or 1,024 megabytes (or 2 to the 30 power).

Optimizing Infrastructure Investments for the 21st Century

by James Creel
ASME Innovative Technologies Institute, LLC

Since the Northeast Blackout, Hurricane Katrina, and the collapse of the I-35W Bridge in Minneapolis, there has been a growing public awareness of aging infrastructures in the United States. ASCE recently assigned a grade of "D" to America's infrastructure along with an estimated $2.2 trillion needed to bring America's infrastructures in line with safety and capacity requirements.[1] Whether it is for roads, bridges, tunnels, rail lines, technological upgrades, "green" improvements, or just plain facility upkeep, hundreds of billions of dollars are being invested annually in various infrastructure projects across the country.[2]

It is reasonable to ask how the money will be invested, especially with the recent passage of the American Recovery and Reinvestment Act of 2009. What elevates one project over another? What criteria are used to prioritize investments? Are certain cities, states, or regions throughout the United States in greater need of these investments than others? Are proper risks and benefits weighed in an effort to optimize such investments? A blue ribbon commission, sponsored by the Center for Strategic and International Affairs, examined these questions and concluded that not only is America investing too little in aggregate, but America is investing in the wrong things. The commission found that we are poorly prepared to optimally allocate these massive funds.

This results in considerable opportunity losses as billions of dollars are potentially misspent. Elected leaders representing the interests of different states and districts can certainly tout the merits of one project over those of another. Highly paid lobbyists can do the same. The "stove-piped" nature of the allocation process from appropriations to breaking ground, earmarks, out-dated formulas, and block grants can distort from optimal investment.

What is missing is an objective, analytic approach that allows value, security, and resilience to be maximized relative to cost by the President, governors, and mayors.

ASME Innovative Technologies Institute, LLC (ASME-ITI), has convened a group of distinguished experts to address this immense national challenge. The ASME-ITI Working Group on Infrastructure Investment has produced a feasibility study of a methodology to guide how to invest taxpayer dollars wisely, strategically, and transparently. The report defines goals and necessary design requirements to allocate capital in a feasible manner according to systematically weighted national objectives. The process, developed by analogy with financial portfolio optimization, is summarized in the table on page 25.

The logic and some of the analytic tools of financial portfolio analysis contribute to a feasible approach for infrastructure portfolio optimization, with modifications to account for the differences between financial and infrastructure assets.

(Continued on Page 25)

[1] ASCE, http://www.infrastructurereportcard.org/, (accessed September 15, 2009).
[2] Peter R. Orszag, Director, Congressional Budget Office, "Investing in Infrastructure," Testimony before the Committee on finance, U.S. Senate, July 10, 2008.
[3] Center for Strategic and International Studies Commission on Public Infrastructure, Guiding Principles for Strengthening America's Infrastructure, 2006.

Physical Exam of Aging Buildings

by Peter A. Schkeeper, P.E.

Buildings provide both shelter and a quality of life for their occupants, whether as workplaces, houses of worship, or as homes for family living. Buildings also document the history of a culture. As buildings age, both materials as well as the quality of life within those buildings can deteriorate. This article will discuss the aging of buildings and the importance of Building Inspections to their preservation.

According to a report by Dr. C. Leonard Woolley, director of a joint expedition between the British Museum and the University of Pennsylvania Museum that was excavating in the region of Ur in lower Babylonia, the oldest building in the world that is still standing above ground is a small square temple, built by the Sumerian King Aannipadda, of Ur, about 4500B.C. There are buildings constructed during the Roman Empire, which I have personally visited, that are still being used. Within the United States, the Adobe buildings at Acomo Sky City, a National Trust Historic Site, are reported to have been in use for 1,000 years. The oldest buildings I have inspected are portions of residential buildings reported to date back to the 1600s, including one with a loose stone foundation. I have inspected many commercial and residential buildings that were constructed during the 1700s. Some are in great shape and many are being nursed along. With these buildings, issues often develop at the joints of sections added at different times with dissimilar materials. Deferred maintenance and temporary supplemental support are common practices that prevent a building from aging gracefully. How long a building can last depends upon many factors including the type of foundation, how it is sited, how roof and surface water runoff is managed, construction materials, air quality within the building, and the care afforded the building over the years. Older buildings have a romantic attraction and as with any romance, there are continual and increasing levels of maintenance that never go away.

There are numerous reasons to maintain an older building. A relatively recent environmental reason is that by maintaining older buildings, we do not release the carbon emissions that would result from demolishing the building. When a building becomes unsafe for habitation, then a crucial decisionmust be made: invest in its repair and restoration or destroy it.

Richard C. Diamond, Ph.D., a staff scientist at the Berkeley National Laboratory, issued a 2001 study entitled, "An Overview of the U.S. Building Stock." The following statement is extracted from Dr. Diamond's study, with his permission. While his 2001 study included a chart, a more current chart is shown in Figure 1.

Most commercial buildings, once constructed, are expected to last for decades or longer. New buildings are constructed each year and older buildings are demolished, but the commercial building stock at any point in time remains dominated by older buildings. More than 70 percent of buildings and total floor space in 1995 were constructed prior to 1980, and more than 50 percent of buildings and floor space, prior to 1970. (See Figure 1)

Data regarding the age of residential buildings was complied by the U.S. Census Bureau American Housing

(Continued on Page 12)

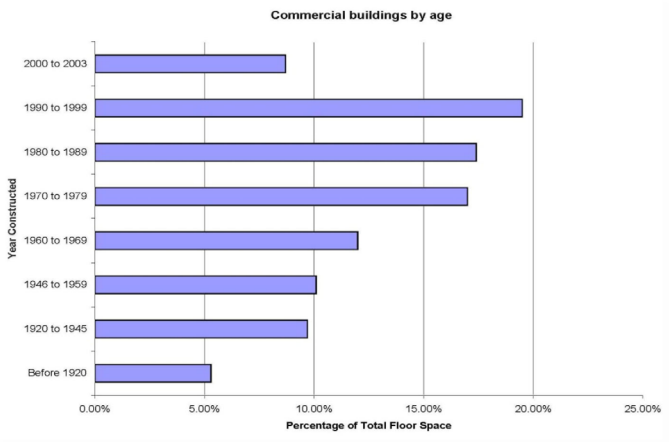

Figure 1: Source: Energy Information Administration

Inspections *(Cont. from 11)*

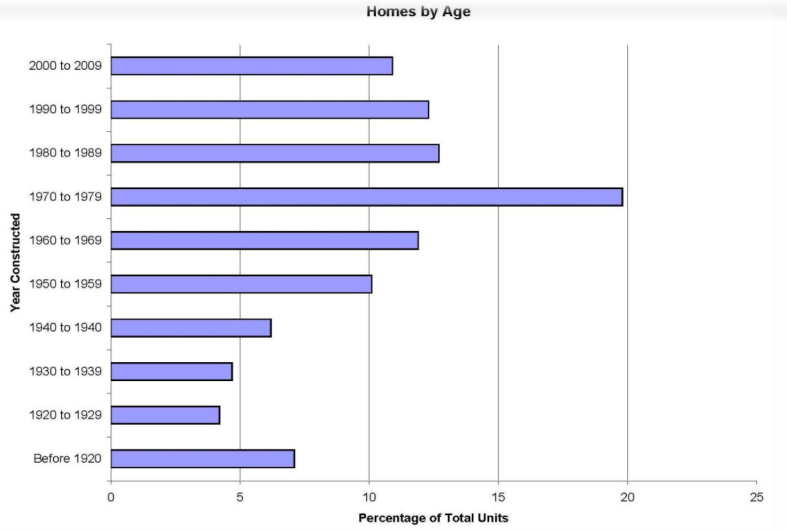

Figure 2: Source: American Housing Survey for the United States in 2007

Survey and is shown in Figure 2. Manufacturing, industrial, farm, and government buildings are not included in any of this data.

Taking Guidance from Building Codes

Building Codes have existed in one form or another for a very long period of time. The Code of Hammurabi, created in 1790 B.C., is generally accepted as the first building code (*If the house the builder built causes death to the owner then the builder is put to death*). Most modern codes have their roots embedded in the effort to reduce fires. Building codes are adopted or adapted by government jurisdictions, either by individual states or by local municipalities. Building Codes have expanded to all aspects of building construction. In the United States, the International Code Council has consolidated the most-used codes, many of which are adapted by states and major cities for their particular needs. Based on www.iccsafe.org, current ICC publications include the following:

- International Building Code®
- International Energy Conservation Code® Provisions®
- International Existing Building Code®
- International Fire Code®
- International Mechanical Code®
- ICC Performance Code™
- International Plumbing Code®
- International Private Sewage Disposal Code®
- International Property Maintenance Code®
- International Residential Code®
- International Wildland-Urban Interface Code®
- International Zoning Code®

In addition to the ICC codes, there are other code-writing organizations with codes that may be adapted or adopted by local or state jurisdictions. There are also many industry standards-writing organizations that are referenced within the codes or within material manufacturer's installation instructions. Manufacturer's installation instructions often contain requirements that are necessary to maintain their independent laboratory testing labeling requirements. Codes apply at the time a building is constructed and when there are modifications to a building. Some jurisdictions have adopted or adapted a property maintenance code that requires updating of the building. These codes are usually associated with periodic inspections. Typically, fire codes will have on-going applicability and be subject to periodic inspections. Thus older buildings that have not been updated continue to stand with construction and systems in effect at the time the building was constructed. Codes are not perfect but they do represent a consensus of current thinking for the minimum requirements. Code writing is a committee function with various interest groups participating in their development. Nothing prevents a building from being constructed and maintained to higher standards of care. Building inspections of existing buildings are typically not code inspections; however a good working knowledge of codes and standards will provide guidance for the Building Inspection Engineer.

Key Issues of Building Well Being

The well being of a building cannot be determined just by its age. Historic buildings that have been well cared for have lasted for

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centuries. New buildings can have serious or catastrophic flaws due to improper construction. Adverse conditions can develop within buildings that seem to take on a life of their own, such as mold. The well being of a building is important, and issues critical to well being, identified by Building Inspection Engineers, can be prioritized as follows:

• Life Safety – Life safety is a preeminent requirement for any building and would be the first priority for repair whenever a building issue develops that could threaten life. Examples include falling facades of taller buildings, balcony failure, fire hazard, and elevator or escalator problems. Even interior air quality considerations can reach the level of Life Safety, as has been demonstrated with Legionnaires' Disease.

• Building Structural Integrity – Building structural stability is not always visually apparent yet often a visual indicator will alert the experienced building inspection engineer that investigation is necessary. One example of a structural issue that is not always obvious is corroding reinforcing steel within reinforced concrete structural support members.

• Water Intrusion – Water intrusion can take on many forms starting with rain water entry through the building envelope including the roof and exterior walls. Condensation at or within the building envelope is yet another source of water intrusion into the building. Ground water and plumbing leaks are additional sources of water.

• Building Functionality – Necessary Building Functions include a building's electrical, plumbing, lighting, heating, and air conditioning systems.

• Energy Efficiency – Energy efficiency has a significant impact on the cost of operating a building and has increased in social responsibility.

• Maintenance Issues – Maintenance Issues include maintaining proper surface conditions on the exterior and interior of the building and routinely maintaining building systems. Deferred maintenance is a major cause of building deterioration. Most maintenance issues can be anticipated and planned for, and preventive maintenance is more cost effective and less disruptive to building operations than waiting for failure.

• Comfort Issues – Comfort Issues include air conditioning and automatic functions such as automatic lighting or automatic toilet flushing.

Building Inspection Engineering

Building Inspection Engineering involves many areas of knowledge. Its growing importance as a discipline over the past 50 years is demonstrated by the number of Professional Engineers and Registered Architects now obtaining Board Certification as Building Inspection Engineers.

A Building Inspection Engineer must possess a broad range of knowledge to function as an effective diagnostician. Board Certification provides evidence of competency to inspect buildings, their systems, structural weaknesses and strengths, and to ensure the safety and health of the building's occupants. The 23 major topics that require demonstrated knowledge and documented experience in order to obtain Board Certification as a Building Inspection Engineer include:

- History of building and construction, including historic preservation
- Building materials
- Construction detailing and techniques
- Structural analysis and theory of structures
- Thermal systems
- Surveying engineering
- Timber and wood frame structures
- Steel structures
- Concrete and masonry structures
- Plumbing/waste management
- Life safety
- Building electrical systems
- Integrated building system design
- Geotechnical engineering
- Building mechanical systems (e.g. vertical transportation)
- Site features, including security
- Building codes and standards, including ADA compliance
- Engineering economics (e.g. cost estimation, financial

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The Future for Sustainable Water Infrastructure

by Lorraine Loken*
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For more than a decade, water infrastructure investment has languished. The gap in funding ($40-150 billion)[1] has deepened as infrastructure deteriorates, creating dramatic scenes of public horror. From cars being swept down the Potomac River last December to massive sink holes swallowing trucks in Manhattan[2] and Fire Engines in Los Angeles[3] to flood waters contaminating public buildings with *Escherichia coli* (E. coli) in New Jersey,[4] collapsing water infrastructure is seizing the public's attention.

Just as the Cuyahoga River going up in flames 40 years ago spurred the Clean Water Act, the Water Sector is hopeful that we may be on a threshold toward political action for sustainable water infrastructure. Experts warn that if we do not take action soon, an entire generation of progress under the Clean Water Act and Safe Water Drinking Act is at risk. At stake, is a dangerous tipping point to a new era, or should we say, old, where water systems become unstable in their ability to deliver, kills fish, and drinking water alerts become an everyday occurrence.

The American Recovery and Reinvestment Act (ARRA) provided a shot in the arm for wastewater and drinking water with funding of $4 billion and $2 billion respectively. However, everyone agrees a one-year increase is not a long term funding strategy. That is why the Water Sector is making a concerted effort to plant seeds toward sustainable infrastructure and funding. While public attention is focused on health care and climate change, the water industry considers their options. The dialogue will escalate in October when water and wastewater leaders meet at the Water Environment Federation (WEF) Technical Exhibition and Conference (WEFTEC®) in Orlando, to debate the future for sustainable water infrastructure. Four 2009 reports have been released to inform the discussion:

- The Aspen Institute, *Sustainable Water Systems: Step One — Redefining the Nation's Infrastructure Challenge*
- American Water Works Association, *Federal Water Infrastructure Bank*
- U.S. Government Accountability Office (GAO), *Clean Water Infrastructure: A Variety of Issues Need to Be Considered When Designing a Clean Water Trust Fund*
- Water Environment Research Foundation, *Strategic Asset Management and Communication Report on Public Communication – Perceptions and Early Communications Tools*

Redefining the Nation's Infrastructure Challenge

The Aspen Institute's *Sustainable Water Systems: Step One — Redefining the Nation's Infrastructure Challenge* seeks to reframe the issue. Rather than focus on the gap in funding, it defines infrastructure needs in sustainability terms. It expands the definition of water infrastructure to include all natural infrastructures that contribute to water quality and supply such as rivers, lakes, streams, groundwater aquifers, floodplains, floodways, wetlands, and watersheds. Embracing this approach, we are directed to pursue

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[1] U.S. EPA, The Clean Water and Drinking Water Infrastructure Gap Analysis (Washington, D.C.) 2002.
[2] NY1 News, February 2, 2009, "Oil Truck Falls into Manhattan Sinkhole," http://www.ny1.com/Default.aspx?ArID=93652, accessed 9/8/09.
[3] Associated Press, September 6, 2009, "Water Main Break Causes Flooding in Los Angeles," http://www.google.com/hostednews/ap/article/ALeqM5geDUvZfc7dzGJd8oa6hV7msLnuEwD9AHV0NO0 accessed 9/8/09.
[4] Environmental Expert.com, September 2, 2009, http://www.environmental-expert.com/resultEachPressRelease.aspx?cid=21001&codi=61638&level=0, accessed 9/8/2009.

Sustainable Water *(Cont. from 14)*

green infrastructure, low-impact development, land conservation, and better management practices for agriculture.

A "Sustainable Path" is articulated in this report to define the ideal situation in which all financial and natural resource costs are managed optimally for safe and reliable water services. Twenty elements were developed covering the full depth and scope of management issues from Public Outreach & Stakeholder Involvement to Energy Management. Several elements mirror the U.S. Environmental Protection Agency's (EPA) *10 Attributes of Effectively Managed Water Sector Utilities* from 2007. The redefinition was born in the paradigm shift toward watershed management that has taken place over the past decade. The report's recommendations promote a holistic approach toward integrated watershed management.

Although the experts were able to reach consensus on what sustainable infrastructure looks like, the "how to" was not an easy agreement. Both the Aspen Institute's report and the U.S. EPA's Attributes emphasize full-cost pricing. They argue that pricing structures which incorporate the full cost to ratepayers lead to market efficiencies in conservation and better environmental decisions. This has become a tension point within the Water Sector as large utilities, some with near crisis needs and high risk scenarios, seek urgent answers that will not break their ratepayers' pocketbooks.

National Infrastructure Bank

Another option for sustainable infrastructure was introduced by the American Water Works Association. The American Water Works Association commissioned a report, *Federal Water Infrastructure Bank*, to determine the efficacy of a National Infrastructure Bank. It is a bank-like financing mechanism with elements of existing programs such as the State Revolving Fund (SRF). Unsuccessful so far, several similar bills have already moved through Congress to establish the funding modeled after the Federal Deposit Insurance Corporation. Its major advantage to other proposals is that theoretically it poses little cost to the federal government.

The Bank's two-pronged approach would provide financial assistance for large water infrastructure projects and reduce the cost of leveraging SRF programs. It would provide direct financing through loans or loan guarantees to larger projects at interest rates at or below the U.S. Treasury Bond rate. The Bank could also purchase or guarantee SRF bonds, lowering their interest rates and allowing SRF programs to make more loans and increase subsidies to communities.

Lending to communities at the Treasury bond rate could save millions of dollars of financing costs. As Bank financing would be in the form of loans and loan guarantees, the main federal budgetary impact would be in the form of additional subsidies provided to reduce interest rates below the Treasury bond rate for communities and SRF programs.

Clean Water Trust Fund

The report, *Clean Water Infrastructure: A Variety of Issues Need to Be Considered When Designing a Clean Water Trust Fund*, published by the GAO, was written to inform Congress about another option. Rep. Earl Blumenauer (D – Ore.) introduced the bipartisan Water Protection and Reinvestment Act in July. It would create a Clean Water Trust Fund to provide a stable and sustainable source of funding for upgrades to wastewater treatment infrastructure.

Currently, local utilities shoulder 97% of investment needs for infrastructure, an estimated $60 billion per year.[5] Many larger utilities argue that looming challenges associated with aging systems, emerging issues, and climate change — droughts, increased storm intensity, sea-level rise, and carbon emissions reduction — are certain to increase needed changes and federal mandates. In addition, the transition to more innovative technologies and approaches such as outlined in The Aspen Institute report will require capital investment to implement. These challenges are pressing at the same time that municipal access to the bond market has become less certain. Without a stable source of funding such as the Transportation

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[5] Kirk, Ken, "Solving the Funding Gap…the Road to a Sustainable Federal-State-Local Partnership" WEFTEC proceedings, Alexandria, Va., 2009.