Bentley Systems

Green Technology For Sustaining Transportation Infrastructure

A National Research Council (NRC) committee on sustainable infrastructure recently noted that using outmoded 20th century methods and materials to develop 21st century infrastructure is likely to yield the same results: increasing instances of service disruptions, higher operating and repair costs, and the possibility of catastrophic, cascading failures. Instead, infrastructure professionals must deploy new project development approaches that incorporate sustainable technology to provide safe and sustainable transportation systems.

"As we think about infrastructure, it's not about replacing a bridge or building a new highway. It's about providing a service," said Rear Admiral David J. Nash, CEC, USN (ret.), president of Dave Nash & Associates, LLC and chair of the Toward Sustainable Critical Infrastructure Systems: Framing the Challenges Workshop Committee. "First, we decide what level of service we expect from our infrastructure, then we choose the approach and technologies that help provide that service."

The Challenge: Shrinking Transportation's Ecological Footprint While Expanding System Capacity To Keep Pace With Rising Demand

The NRC committee reported its findings in the recently published report, "Sustainable Critical Infrastructure Systems: A Framework for Meeting 21st Century Imperatives" (National Academies Press, 2009), which identifies the challenges that will influence how essential services are delivered: remaining economically competitive, reducing dependence on imported oil, reducing greenhouse gas emissions, protecting the environment and conserving natural resources, and developing the capacity to withstand and recover from natural and man-made disasters.

With population and economic growth putting pressure on critical infrastructure worldwide, it is imperative to change the way these systems are planned, built, operated, and maintained so they meet the needs of current and future generations. To be sustainable, infrastructure needs to be physically resilient, cost effective, environmentally viable, and socially equitable, according to the report. "There is a lot of inertia so things may change slowly, but with delivery approaches such as design-build and integrated project delivery, stakeholders are leaving behind their historic rules of conflict and looking to collaborate," Nash said.

Looking at infrastructure as interrelated systems, a holistic and collaborative systems-based approach leverages available resources and provides cost-effective solutions across institutional and jurisdictional boundaries. Applying green technologies in conjunction with innovative project delivery methods reduces the ecological footprint and lifecycle costs. When decisions are based on the expected service level, service life, lifecycle cost, and ecological footprint, developing transportation infrastructure becomes a question of how sustainable the system needs to be.

The trend toward sustainable infrastructure has arisen from the realization that existing transportation systems are unsustainable. "For much of our history, the assumption has been that we have unlimited resources, which includes the capacity of natural systems to accommodate built facilities and absorb waste," explained Prof. Sarah Slaughter, senior lecturer at the MIT Sloan School of Management and coordinator of the Sloan Sustainability Initiative. "We're finding that we don't have infinite resources - which includes fuel - and there is increased awareness of the fragility of our ecosystems."

As vice chair of NRC's workshop committee, Slaughter helped identify issues surrounding how to design and build sustainable infrastructure, which the committee defined as meeting today's economic, social, and environmental needs while enhancing the ability of future generations to meet

their economic, social, and environmental needs.

Currently, these needs are not being adequately met. The widely publicized 2009 Report Card issued by the American Society of Civil Engineers assigned the grade of D to U.S. infrastructure, which has deteriorated in part due to decreased spending. In "An Infrastructure Vision for the 21st Century" (NGA Center for Best Practices, 2009), the National Governors Association noted that the United States now spends just 2.6 percent of its gross domestic product (GDP) on infrastructure, while China invests up to 12 percent, Japan invests 10 percent, and India and the European Union each spend 5 percent.

The transportation sector generates 10 percent of GDP worldwide, so spending levels of 10 to 12 percent are commensurate with the sector's contribution to society. At the same time, however, transportation causes a disproportionate amount of environmental damage. According to the American Association of State Highway and Transportation Officials (AASHTO), transportation is responsible for 22 percent of global energy consumption, 25 percent of fossil fuel burning, and 30 percent of air pollution and greenhouse gas emission.

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In the 2007 report, "Transportation: Invest in Our Future," AASHTO recommended a triple bottom-line approach to sustainable transportation infrastructure development. That means evaluating and optimizing system performance based on three equally important imperatives: economic growth, social equity, and environmental stewardship.

These issues are now being addressed at the national, regional, local, and project level. At the national level, for example, U.S. policies such as the Safe, Accountable, Flexible, Efficient Transportation Equity Act of 2005 (SAFETEA-LU) provide planning guidelines to address sustainable transportation goals.

At the regional level, transportation systems are being optimized to support the economy through effective and efficient operation in business districts, travel demand management in congested areas, and expansion in economic development corridors. Instead of building new facilities to meet increasing demand, policy makers are looking to more effectively use existing capacity. For example, rather than resizing roads to accommodate more trucks, there may be incentives for shipping by rail or water.

Social equity goals are being supported at the local level by improving quality of life through context-sensitive design, multimodal solutions, and equitable land use policies. Reflecting on lessons learned from Hurricane Katrina, Slaughter noted, "We need to think about not just normal operating conditions, but also conditions in extreme events-storms, hurricanes, blizzards-and look at the role of critical transportation services. You have to think about how you evacuate all the people from the affected area in a safe way".

At the project level, transportation systems that harmlessly coexist with ecosystems meet the goal of environmental stewardship. Planners are now thinking about the intersection between infrastructure and the environment in a more holistic way. For example, a green highway can pass through a natural habitat and cause minimal contamination by deploying swales to catch runoff that is treated locally. In an urban area, using more permeable surfaces for sidewalks and pavement can decrease runoff and increase groundwater recharge.

Applying Green Technologies

The Green Highways Partnership (GHP) is a voluntary, public/private initiative that seeks to make sustainability the driving force behind infrastructure development. Participants include the U.S. Environmental Protection Agency, U.S. Federal Highway Administration, and Maryland State Highway Administration, as well as several state departments of transportation.

GHP promotes the use of green technology, which encompasses an expanding group of methods and materials for achieving sustainability goals. These include best practices

such as integrated planning and lifecycle analysis; tools such as building information modeling and smart technology; and materials such as porous pavement and recycled hot mix asphalt.

There are now technologies available to monitor infrastructure condition and performance, new materials for construction and repair, and systems that are self-diagnosing and self-repairing - all leading to fewer service disruptions, lower lifecycle costs, and greater resiliency. Intelligent highway systems, for example, aid in demand management initiatives that charge a premium to access facilities during peak hours.

Applying the principle of congestion pricing, the City of London charges vehicles 8 pounds to enter the central city between 7 a.m. and 6 p.m., Monday-Friday. The charge has reduced congestion by 40 percent and round-trip times by 13 percent. Other cities have followed this example with comparable results.

Not every problem requires a high-tech solution. More than two-thirds of peak-hour traffic occurs in congested conditions, resulting in 2.9 billion gallons of wasted fuel and 4.2 billion hours of lost time in the United States. The Federal Highway Administration estimates that 5 percent of this congestion is due to poorly timed traffic signals. Improved signal timing alone could save up to 145 million gallons of fuel each year.

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The vision for a sustainable society is slowly being realized through the adoption of best practices in sustainable design, application of green technologies, and participation in collaborative approaches to transportation system planning and development. While progress is being made, there is much more to be done.

"What we need is a new way of thinking, in which we look at infrastructure holistically," Nash said. "We need to bring together the best and brightest of our professionals and policy makers, who understand all aspects of these systems, and begin to frame the questions, look for answers, and make recommendations."

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Sustainable Transportation Defined

The widely accepted definition of sustainable transportation was put forth by ministers of transport from 15 European Union countries. It states:

A sustainable transport system is defined as one that

- Allows the basic access and development needs of individuals, companies, and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations
- Is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development
- Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses nonrenewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise

Transportation Projects That Promote Sustainability

Bentley CEO Greg Bentley recently reflected on the vital role that infrastructure plays in sustaining society and the environment at the Chester County Economic Development Council Business Achievement Awards Dinner, at which he was inducted into the Chester County Hall of Fame for outstanding achievement in the business community.

"Infrastructure is about sustaining our productivity and supporting our quality of life," Bentley said. "Every infrastructure asset has an intended design capacity and design lifetime, and we've too often exceeded both. As we reinvest to replace obsolete physical infrastructure, we have the opportunity to create more intelligent infrastructure assets."

The Bentley user community continues to apply the firm's software solutions to infrastructure projects that support sustainable economic growth, social equity, and environmental stewardship around the world. Below are just

some of the innovative projects included in Bentley's The Year in Infrastructure 2008, an annual publication that recognizes projects that demonstrate the superior vision, innovation, and unwavering commitment to best practices of the infrastructure professionals who designed and built them:

California Transportation Corridor: SR75/282 will improve safety and relieve congestion between the San Diego Coronado Bridge and Naval Air Station North Island, part of the largest aerospace-industrial complex in the U.S. Navy. (Parsons Brinckerhoff)

Florida Bridge Restoration: Rehabilitating the Bridge of Lions in St. Augustine, Fla., will preserve a 1927 landmark listed in the National Register of Historic Places and conserve resources that would have been consumed by a replacement structure. (Reynolds, Smith and Hills)

Washington Multimodal Bridges: Context-sensitive design for the Aurora Multimodal and Interurban Bridges project will improve safety for vehicles and pedestrians traveling a three-mile corridor in Shoreline, Wash. (CH2M HILL)

European High-Speed Rail: A 621-kilometer link of the Trans-European Transport Network between Spain and France will cut Madrid-Barcelona travel time by 50 percent and reduce reliance on air and automobile travel in the European Union. (Sacyr)

China Cable-Stayed Bridge: The 1-kilometer-long Stonecutters Bridge will provide service to and from Hong Kong's International Airport, alleviate congestion on arterial roads, and enhance transportation to container terminals. (Arup)

India Bridge Between Districts: A new bridge over the River Rupnarayan will connect the West Midnapore and Hooghly districts in India, impacting the lives of 15 million people. (Development Consultants)

Nepal Paved Roads: Upgrading 17 unpaved roads in a 27,500-square-kilometer area of the Terai region will improve mobility, decrease the cost of commerce, reduce energy consumption, and raise the standard of living for 1.7 million inhabitants. (RITES)

Algeria High-Speed Rail: The 640-kilometer line located on a 1,000-meter-high plateau in the Atlas Mountains of North Africa will be critical to economic development in the lightly populated region. (Bernard Ingenieure)

South Africa Airport Terminal: Integrating the existing international and domestic terminals at OR Tambo International Airport in Gauteng, South Africa, will accommodate a 26 percent increase in passenger throughput. (Bentel Associates International)

Sustainable Transportation Indicators

The Center for Environmental Excellence by AASHTO advises transportation professionals to use indicators that reflect their goals for sustainable transportation. An effective performance measure passes the "four-R test: relevant, robust, repeatable, and responsive." These indicators quantify:

- Economic outcomes: ease of access, operation costs, productivity, efficiency, cost-benefit, transport diversity, smart growth
- Social outcomes: accessibility, affordability, safety, security, health and fitness, community livability, equity, working conditions
- Environmental outcomes: resource conservation, ecological intrusion, emissions to air, soil, and water, habitat protection, land use impact

Using indicators such as average commuter travel time, per-capita crash fatalities, and per-capita climate change emissions, transportation officials are more effectively measuring and improving the performance of transportation infrastructure throughout the lifecycle.

Paving The Path To Sustainability

The 2009 Bentley Roads and Bridges Conference, which will take place Oct. 19-21 in Charlotte, N.C., is the first joint conference for users that will provide a convenient opportunity for infrastructure professionals to increase their knowledge of Bentley software and refine their technical skill in applying it. In addition, those who take advantage of this training will earn professional development learning units for each conference course they attend.

The theme of the event is "Celebrating 20 Years of 3D Modeling" to recognize the 20th anniversary of the release of Bentley's first civil engineering design products. The conference features more than 160 hours of sessions and workshops for both new and experienced users of InRoads, GEOPAK, LEAP Bridge, RM Bridge, Haestad Methods, and other Bentley civil engineering software. (Refer: www.bentley.com/RBC)