

# Exploring Green Highways

**ASTM International sponsored James Bryce's participation in the Washington Internships for Students of Engineering program this year; he adapted his paper on green highways for *SN*.**

**BY JAMES M. BRYCE**

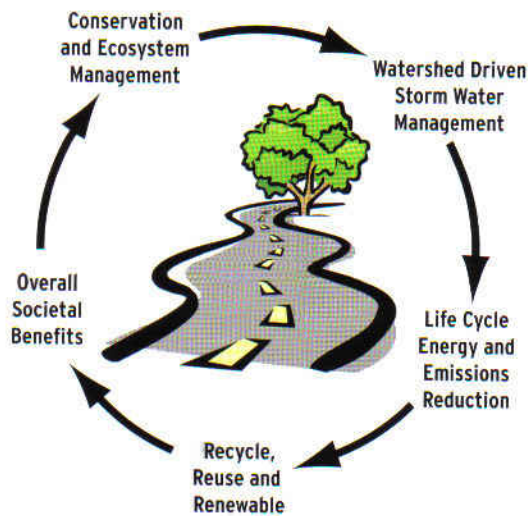
Americans combine to drive over 3 trillion miles annually on more than 4 million miles of roads. Soaring gas prices and the fear of global warming have caused many people to become much more environmentally conscious by driving less and buying green. And while many Americans are struggling to purchase more efficient cars in order to help their wallets as well as the environment, few Americans realize that the roads they drive on could be more economically and environmentally sustainable.

Many technologies already exist to reduce the environmental impact of highways, such as the advanced planning, intelligent construction and efficient maintenance techniques commonly used in modern highway design. Yet current industry practice tends to focus on the short-term costs of road building, often neglecting ways to lower long-term or life cycle costs through more sustainable highway construction.

A "green" highway rating system would provide a way to update current state and federal highway best management practices to include advanced recycling techniques, extended environmental mitigation and extensive energy reduction. Such a system would classify the various parts of the highway construction process and then rate them based on their environmental sustainability. This approach would be beneficial to the design and construction of new surface transportation systems as well as the maintenance of existing transportation infrastructure.

However, there are several challenges to developing a green highway system. A standard definition for sustainability in highway design currently does not exist. Developing a green highway rating system would require cooperation between government agencies. As well, many standards needed for transportation system materials and testing still need to be developed.

**A green highway may not look much different than a normal highway at first glance, but with closer inspection a driver will notice subtle differences.**



**Figure 1 – Five Key Areas for Green Highways**

### WHAT IS A GREEN HIGHWAY?

Green highways are a relatively new concept although the implementation of technologies involved in green highway design has been encouraged for many years.

A green highway may not look much different than a normal highway at first glance, but with closer inspection a driver will notice subtle differences. More plant life grows along the shoulder, and more trees are planted as wildlife buffers. In towns, highways become more aesthetically pleasing, and in rural areas highways become a more natural part of the environment.

A green highway can be defined by five broad topics, each of which includes various aspects (Figure 1).

### KEY FEATURES OF GREEN HIGHWAYS

#### WATERSHED DRIVEN STORM WATER MANAGEMENT

Watershed driven storm water management is significant in reducing the storm water runoff from a highway as well as treating the runoff. Storm water management practices are incorporated into many highway designs. Bio-swales are being implemented along neighborhood roads and along impervious parking lots to slow and treat storm water runoff in Portland, Ore. Many projects also incorporate wetlands, which act as natural water treatment processes, alongside the highway.

#### LIFE CYCLE ENERGY AND EMISSIONS REDUCTION

Energy is a foremost economic concern. A significant amount of energy goes into producing materials for the road as well as constructing and maintaining it, and energy is consumed by vehicles sitting in congested traffic on a poorly de-

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signed road. To counteract the amount of energy embodied in concrete, much research has been conducted on materials such as fly ash and slag to replace a large portion of cement. The use of one ton (0.9 metric ton) of fly ash as a substitute for one ton (0.9 metric ton) of cement in concrete can have a total primary energy reduction of 4.5 million BTUs (4,695 megajoules),<sup>1</sup> or the equivalent of the energy used in burning 39 gallons (147 liters) of gasoline.<sup>2</sup> Given that cement production is estimated to reach 202 million tons (183 million metric tons) in the year 2020,<sup>3</sup> substituting 50 percent fly ash for cement could save the equivalent energy of 6.4 billion gallons (24 billion liters) of gas annually.

### RECYCLE, REUSE AND RENEWABLE

Using recycled materials in highway design can significantly reduce the amount of materials going into area landfills as well as reduce the amount of virgin material pits required in highway construction. Recycled materials can be classified in several subcategories based on their production, and recycled materials components are a type of recycled material that is derived from industrial byproducts. It has been found that the use of RMCs can notably reduce energy consumed by a highway, reduce greenhouse gas emissions and reduce the overall roadway cost. Some results from a 2004-2005 study on the use of RMCs for the two combined years are:

- ▶ Reduced energy use of 30 trillion

BTUs (31.5 billion megajoules),

- ▶ Avoided carbon dioxide equivalent air emissions of 4.2 million tons (3.8 million metric tons), and
- ▶ Realized water savings of more than 55 million gallons (2.1 billion liters).<sup>4</sup>

### CONSERVATION AND ECOSYSTEM MANAGEMENT

Ecosystem management includes many techniques to reduce highway impact on the natural environment. In an article published in the *Journal of the Transportation Research Board*, J.F. Morrall and T.M. McGuire discuss the effects of ecosystem management incorporated into the design of a highway in the Canadian Rocky Mountain Parks. According to the research, providing animal crossing structures and underpasses reduced vehicle-wildlife collisions as much as 97 percent.<sup>5</sup>

### OVERALL SOCIETAL BENEFITS

For many years sustainability has been defined as a tool focused on the natural environment, and effects on the man-made environment have been overlooked. However, in a holistic approach to sustainable construction, overall societal benefits should be taken into account. Highways have an important impact on local economies. An aesthetically appealing highway design can draw business into a community and supply local jobs and tax income, whereas a poorly designed highway can decrease traffic to a business and eventually cause the business to seek a better location.

### THE U.S. HIGHWAY SYSTEM

The U.S. highway system is a vast network vital to our nation's economy. However, increasing public transportation ridership and aging roadways have left highways in a deteriorating condition. The age and condition of America's infrastructure has compelled much discussion about the upcoming reauthorization of the surface transportation act, SAFETEA-LU, or **Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users**.

SAFETEA-LU, which will be a focus for the 111th Congress, authorizes federal surface transportation programs for highways until 2009.<sup>6</sup> Surface transportation acts are an integral part of funding research for the advancement of highway systems, and research centers are responsible for developing and implementing new and beneficial technologies in the highway system.

### CURRENT GREEN HIGHWAY RATING SYSTEMS

**Green Roads** was developed by Washington State researchers in 2007. Green Roads is a rating system for measuring roadway sustainability; it is based on assigning point values to a road according to broad topics much like some green building rating programs.

Preliminary research on the Green Roads system has shown that it can be implemented in Washington state with promising outcomes. However, Green Roads needs extensive research to be implemented in areas outside the Northwest. In addition, much concern has been expressed by professionals in the Federal Highway Administration and the U.S. Environmental Protection Agency that any rating system will need to be dynamic. Many technologies either are not relevant to every U.S. region or cannot be transferred to different regions without extensive retrofitting.

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### **PARTNERSHIPS FOR GREEN HIGHWAYS**

Many partnerships exist to work with federal agencies on the development of sustainable infrastructure. These partnerships work to inform or educate federal agencies about technologies available for the construction and maintenance of public infrastructure. Two such partnerships that are integral to green highways are the Recycled Materials Resource Center and the Green Highway Partnership.

### **THE RECYCLED MATERIALS RESOURCE CENTER**

The Recycled Materials Resource Center works hand in hand with federal highway programs in order to promote the use of recycled materials in highway projects. In June 1998, the Transportation Equity Act for the 21st Century was passed in order to better fund federal highway projects. The funding allocated to the FHWA by the act was used for the conception of the RMRC. RMRC has grown in the past 10 years to include campuses at the University of New Hampshire and the University of Wisconsin, both of which research the beneficial use of recycled materials in highway construction. The ultimate objective of RMRC is to increase the wise use of recycled materials in roadway construction and maintenance. The purpose is to decrease the amount of materials going to landfills or stockpiles

and to reduce the cost and environmental impact of U.S. Department of Transportation projects.<sup>7</sup>

### **THE GREEN HIGHWAY PARTNERSHIP**

The Green Highway Partnership comprises many state and federal agencies that work together toward the development of green surface transportation systems and technologies through research and related activities. According to their motto, "The GHP is a voluntary, public/private initiative that is revolutionizing our nation's transportation infrastructure." Through concepts such as integrated planning, regulatory flexibility and market-based rewards, GHP seeks to incorporate environmental streamlining and stewardship into all aspects of the highway lifecycle.<sup>8</sup>

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### **DEVELOPING STANDARDS FOR USE IN A GREEN HIGHWAY RATING SYSTEM**

A green highway rating system will foster the development of technologies based on the many criteria used for evaluating a highway. Standards will play an integral role in defining sustainability as well as developing sustainable technologies. The use of standards assures that identical practices can be reproduced with similar results, and reproducibility is an important part of assuring that classifications can be made with as little bias as possible. Many standards have been developed on the subject of sustainability. For example, ASTM International currently has more than 500 standards related to sustainability.

Many standards can be applied to the design, cost analysis and risk analysis involved with the construction of green highways. ASTM standard E1804, Practice for Performing and Reporting Cost Analysis During the Design Phase of a Project, has been used by transportation professionals to set up a framework for project estimation. ASTM standard D7229, Test Method for Preparation and Determination of the Bulk Specific Gravity of Dense-Graded Cold Mix Asphalt (CMA) Specimens

by Means of the Superpave Gytratory Compactor, has aided in the process of extending the use of cold mix asphalt in the U.S., consequently reducing energy consumption of the highway.

## OBSTACLES TO IMPLEMENTING GREEN HIGHWAYS

Before any new technology can be introduced in society, it must be verified by a consistent history and accepted as safe for use. Most techniques that will lead to the creation and implementation of a green highway system are very young. Standards and research will aid in the development of a track record for technologies, but implementation of technology requires performance assurance.

In addition, some concerns about green highway rating systems can be found within government. One view in FHWA is that implementing green highway classifications is premature and counterproductive.

## SUSTAINABLE HIGHWAYS IN A GLOBAL VIEW

In 1999 the FHWA helped sponsor a team of researchers to travel to four countries in Europe to explore international practices in highway sustainability. Each of the countries visited has implemented programs to increase the number of sustainable construction projects as well as raise public awareness on the overall need for sustainability. Each country decided to implement extensive research into ways to increase recycling while still maintaining a strong infrastructure. One deciding factor in these moves toward sustainability was the increase in land use and the reduction in availability of landfill space. Many more research trips have been conducted and have discovered that sustainability in many European countries has traversed scientific research and traveled into the general public's interest.

To read the full text of this paper, go to [www.wise-intern.org/journal/2008/JamesBryceFinal.pdf](http://www.wise-intern.org/journal/2008/JamesBryceFinal.pdf).

## CONCLUSIONS

The development of green highways will play an important role in the effort to mitigate man-made impacts on the natural environment. The market for green construction is being explored and expanded. Many disciplines have realized the benefits of sustainability. Green construction has taken place in the structures market and has had positive results with the development of green building rating systems. However, success in private markets does not automatically translate into success in the public sector. Highways are publicly owned and funded, and new innovative techniques must be developed for sustainable highways.

The U.S. has consistently been at the forefront of technological advancement and has traditionally placed emphasis on the need for integrated infrastructure and efficient, low-cost construction. However, with the fear of man's increasingly irreversible impact on the natural environment, new infrastructure goals need to be recognized.

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