

Partnerships for Sustainability
A New Approach to Highway Materials

A

Report on the Houston Workshop

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By

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Preface

To conduct a workshop on recycled materials is far from a new idea. Maybe two to four significant recycling efforts are conducted nationally each year. To ask that highway materials and environmental specialists from the individual state Departments of Transportation meet at the same workshop adds quite a different twist to the conventional workshop theme. But then, to add individual state Departments of Environmental Protection and beneficial use specialists along with the Federal Highway Administration, (FHWA), the U.S. Environmental Protection Agency (EPA), the American Association of State and Highway Transportation Officials (AASHTO), the American State and Territorial Solid Waste Management Officials (ASTSWMO) and mix them with some very important European recycling specialists might really start to attract attention.

Why assemble this very diverse crowd? In September 1999, representatives from the above groups visited Sweden, Denmark, Germany, the Netherlands, and France under the sponsorship of the FHWA and AASHTO International Scan Program and the Recycled Materials Resource Center (RMRC) at the University of New Hampshire. The objective of the study was to review and document innovative policies, program and techniques that these European countries may have on recycling construction materials.

This report documents this very creative workshop. The opinions represent a consensus of disciplines that heretofore had not worked on this common issue. All brought their own specialty to the workshop but found a way to meet on common ground. For the most part, the opinions represent a “view for the middle” – middle managers and specialists that would like to unite on common recycling ground.

Special thanks go to the Federal Highway Administration, the Texas Department of Transportation, and the RMRC for financially and technically sponsoring this workshop. Our final thanks go to our European guests who gave of their time and energy to support the workshop.

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Executive Summary

Background

In September 1999, the International Technology Scanning Program conducted a recycled materials technology scanning tour to Denmark, Sweden Germany, the Netherlands, and France in September 1999. This scan jointly sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the Recycled Materials Resource Center (RMRC)¹ at the University of New Hampshire and included support from the U.S. recycling industry. The purpose of the scan was to review and document innovative policies, programs and techniques in Europe and to evaluate their applicability to US practices. This report documents a workshop that was conducted in Houston, TX in October 2000 for the express purpose of exploring ways of implementing scan findings.

The first day of the workshop was dedicated to knowledge sharing. Nearly ninety attendees heard presentations from European and U.S. specialists. On the second and third days, state Departments of Transportation (DOT), FHWA, and U.S. Environmental Protection Agency (EPA) officials, engineers and environmental staffs caucused to 1) find common ground and 2) encourage working together on all aspects of recycled materials use within the highway environment. Attendees include forty-five state DOT materials specialists, state DOT environmental specialists, and state EPA beneficial use specialists, a community that had never formally met in any national or regional setting. In addition, this was the first time that highway officials representing AASHTO had met in a working atmosphere with the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) officials.

Program Overview

All presentations and discussions promoted the theme that recycling gains will only come from improved partnerships and integrated methodologies and approaches. Beneficial use specialists, along with producers of solid waste, continue to see the highway facility as a significant sink. They agree that significant recycling gains will only come with early and continuous cooperation. DOT officials agreed, noting their lack of in-depth knowledge and experience with this area of environmental procedures and methodologies.

Key Findings and Recommendations

The Scan Team identified examples of European cooperation among government, the construction industry, and the environmental groups. This cooperation has produced

¹ The Recycled Materials Resource Center (RMRC) at the University of New Hampshire is a national center created to promote the wise use of recycled materials (pavements, secondary, waste, and byproduct materials) in the highway environment. The Center is a partnership with the Federal Highway Administration.

some very positive results. European countries do believe that transportation sustainability is possible and attainable and that sustainability within the highway material program is a specific but achievable goal as well. They seem more willing to employ targeted taxation as a means to creating incentive. Even though this policy is generally not viable in the U.S., European practices still deserve serious assessment and scrutiny. This should be done by joint working groups with representation from the highway and environmental communities. The official Scan Report is now available and contains many examples of cooperation.

Several European countries have research programs that evaluate the in-service recycled material performance. This approach directly challenges the principle that recycled material must meet virgin material specifications.

Attendees also agreed that U.S. working partnerships must advance at all levels – FHWA and U.S. EPA; AASHTO and ASTSWMO; and state DOTs and EPAs. Under new and more aggressive working relationships, these organizations would show the leadership required that would enhance cooperation, technology sharing, and program streamlining in all levels of government. It was recommended that the above four organizations initiate a more formal working relationship by establishing a Highway Materials Sustainability Joint Committee that includes all the appropriate disciplines, including cities and counties.

Neither FHWA nor AASHTO have clear recycling policies. Both organizations would give a clearer indication of the importance of recycling and sustainability if they did. It was recommended that this topic be pursued by each individual agency and be an early discussion topic for with the Joint Committee recommended previously.

Only five state DOTs are known to have full time recycling coordinators. These states – TX, MA, PA, NC, and CA - have reaped positive benefits from their programs. The coordinator acts as the focal point to connect state DOT, state EPA, solid waste producers, and potential entrepreneurs to promote increased waste material use and to reduce barriers. Other states DOTs are encouraged to establish similar recycled material coordinator positions. State EPAs would also benefit significantly from such a position within their organizations.

Resources for formal technology information sharing are relatively limited. All participants argued for more web-based sharing of experiences, reports, needs, etc. It was recommended the RMRC should play a pivotal role in this area.

Many other significant ideas were generated at the meeting and merit further exploration. They include:

- Developing a synthesis of DOT recycling material practices, including specifications and test methods
- Adding more environmental requirements into material specifications
- Developing a working definition of “sustainability”
- Developing a long-range research and implementation plan

- Developing jointly sponsored technology transfer outreach programs, such as demonstration projects, workshops, pamphlets, and training efforts. Some attendees suggested that the legislative branch of all governmental entities should be involved in the type effort as well.

The recommended Joint Committee could include all the above as part of their cooperative efforts.

The RNRC has made contributions towards such a goal but not on a strategic large-scale national level. The proposed sustainability committee would give RMRC work the needed boost to reach out to a much wider community interested in promoting sustainability in highway materials.

The AASHTO Standing Committee on the Environment (SCOE) has limited resources. Most are associated with environmental analysis and permitting associated with the National Environmental Protection Act (NEPA). It was recommended that SCOE members participate actively in such a Joint Committee effort. SCOE representatives, however pro-active they may want to be, need to undertake a serious dialogue on resource availability. Engineering and economic analyses, along with possible development of environmental testing standards, will be difficult to add to an already full agenda.

It was also suggested the material usage and demands, recycling, off-site removal, and other recycling issues be considered in the Environmental Impact Statements. Some also suggested that materials be considered in a systems planning approach. This suggestion is clearly worthy of consideration but within the contexts of SCOE responsibilities and the proposed Joint Committee.

Neither AASHTO nor Association of State and Territorial Solid Waste Management Officials (ASTSWMO) representatives were familiar with each other's organization or how the other dealt with recycled materials issues. ASTSWMO works on recycled materials and just recently completed a very significant report on the beneficial use of recycled materials. ASTSWMO had little formal contact with highway officials on this work.

Conclusions

Progress in the use of recycled materials has been appreciable in the highway community over the last 20 years. However, future progress is dependent on more cooperation among various disciplines -- industry and government, highway engineers and environmental specialists. While the European experience does allow for incentive or preferential taxation policies, the American experience will have to rely on its ability to form partnerships and alliances. Most in the workshop believe this can happen.

Partnerships for Sustainability A New Approach to Highway Materials

I. Background

The Federal Highway Administration's (FHWA) International Technology Scanning Program sponsored a scanning tour to Denmark, Sweden, Germany, the Netherlands, and France from the 10th to the 26th of September 1999. This scan was also sponsored by the American Association of State Highway and Transportation Officials through their National Cooperative Highway Research Program (NCHRP) Panel 20-36 on "Highway Research and Technology -- International Information Sharing" and by the RMRC.

The International Technology Scanning Program's mission is to benchmark foreign technical and managerial practices for the benefit of the U.S. highway community. The objective of the Recycle Scan was to review and document innovative recycling policies, programs and techniques. The delegation met with over 100 representatives from European Transportation and Environmental Ministries, research organizations, contractors, and material producers involved with recycling programs.

The delegation concluded that the European practices were of sufficient importance that they should be presented and evaluated in the U.S. at a national workshop.

A Steering Committee of key scan members was formed and set the following objectives:

- Share knowledge on both U.S. and European experiences
- Find common ground and areas of interest and concern
- Build new alliances and partnerships

The Steering Committee, building off the European experience, saw two payoffs in such a workshop:

- To partner with their environmental agency counterparts
- To identify, prioritize and achieve consensus on needs and develop a common agenda.
- To reframe recycled practices in terms of sustainability so they might better be understood and resolved

Sustainability is an emerging concept in specific highway construction and materials disciplines. In 1987 the United Nation's Brundtland Commission Report identified sustainability as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." As stated in various United Nation documents, sustainable development, at its simplest, is development based on patterns of production and consumption that can be pursued into the distant future without degrading the human or natural environment. It requires, within each nation's

technological and social capabilities, the wise management of resources and the equitable sharing of the economic benefits.

The American Association of Engineering Societies (AAES) in their publication “The Role of Engineering in Sustainable Development” stated that “human civilization has crossed a historical divide where, to endure our long-term survival, we must learn to ‘meet the needs of the present without compromising the means for future generations to meet their own needs.’” This publication was the result of a combined effort of the AAES and the World Engineering Partnership for Sustainable Development. The object of this alliance was to inform practicing engineers, engineering students, and the general public of the importance of sustainable development.

The AAES also published action principles for the engineering profession. They include 1) engineer engagement in shaping decisions; 2) sustainable development education for the profession and the public; 3) integrated systems thinking and synthesis; 4) new environmental-economic measures and analysis; 4) sustainable technologies and processes; and 5) expanded multidisciplinary partnerships. More information on AAES can be found at AAES.org.

The Netherlands has a very noteworthy sustainability policy that requires economic policy, spatial planning policy, and environmental policy to be developed together. The underlying principle is that economic growth should only occur if pollution declines at the same time. They are very deliberate in merging various national policy lines together.

II. Opening Session

The workshop opened with an introduction by Ms. Katherine Holtz of the Texas DOT. She was followed by Mr. Vince Schimmoller of the FHWA, Ms. Jean Schwab of the U.S. EPA, and Mr. E. Dean Carlson of AASHTO. All officials support the need for better cooperation and that recycling needs an integrated approach. Mr. Schimmoller believes that an integrated program could be prepared in advance for the next highway reauthorization. It should address and support a cooperative, rather than a regulatory approach to recycling issues. Mr. Carlson noted that more should be done in the recycling area but that there has been some backlash from the ISTEA-forced use of crumb rubber. The resources to change the requirement were extremely high. The legislation may even have been counterproductive in promoting the use of crumb rubber. Ms. Schwab believes that EPA would be very open to working with all concerned parties in a cooperative spirit, especially in the area of the comprehensive procurement guidelines². The EPA, however, is severely restricted with few, if any, discretionary funds for them to conduct outreach programs.

² The Comprehensive Procurement Guideline (CPG) program is part of EPA's effort to promote the use of materials recovered from solid waste. The CPG program is authorized by Congress under Section 6002 of the Resource Conservation and Recovery Act (RCRA) and Executive Order 13101. EPA is required to designate products that are or can be made with recovered materials, and to recommend practices for

The opening remarks were followed by presentations aimed at stimulating discussion, especially during the brainstorming segment of the workshop.³ The keynote presentation was entitled, “Life Cycle Assessment of Civil Infrastructure Systems,” and presented by Dr. Arpad Horvath of the University of California at Berkeley. Dr. Horvath’s presentation addressed several of the many technical, economic, and environmental factors in sustainable development, which require interdisciplinary approaches, and private and public partnerships. While sustainable development and better environmental quality are becoming important social goals, their analysis and implementation are complicated by the existence of so many interdisciplinary factors. Dr. Horvath explained how life-cycle assessment (LCA) is emerging as the most promising approach to such an analysis. Dr. Horvath also presented what is considered to be the state-of-the-art model in LCA and he provided some real life examples, comparing asphalt with concrete pavements.

Dr. Taylor Eighmy of the Recycled Materials Resource Center (RMRC) presented a national look at the recycling efforts in the U.S., a review of EPA and Environmental Council of States activities, the ASTSWMO beneficial use survey, and the activities underway at the Center. The Center is supported by a cooperative agreement with the FHWA.

Several European representatives were invited to the U.S. to present their programs and share their experiences. Dr. Jan van der Zwan, Ministry of Transport, Public Works, and Water Management in the Netherlands, discussed the Netherlands approach to recycling. The Netherlands has formal legislation encouraging recycling in the highway environment as part of their broad sustainability policies. The Netherlands is extremely successful in recycling the highway environment. He reiterated that each country has its own culture and must integrate recycling into that culture. Government must set the preconditions (policies) for improving the recycling atmosphere. Industry must develop its own sales efforts, invest in recycling, organize themselves, understand the social problems, and work to locate markets for their products. Both must work together to set research agendas and technical standards.

Mr. Karsten Ludvigsen, RGS 90, Denmark, presented his company’s total concept for recycling and selling recycled materials for the construction industry. The RGS 90 is a unique company with significant ownership by the public sector. RGS 90 was formed as a result of Denmark’s unique lack of natural resources and its assertive governmental taxation policy. He presented the Copenhagen example of full recycling where literally all materials in a building or roadway will be sorted for reuse in highway construction. He reiterated that it is market economics that fundamentally drive such a policy.

Dr. Hans van der Sloot of Netherlands Energy Research Foundation (ECN) talked about the European leaching protocols. The talk centered around the ECN leaching database on

buying these products. Once a product is designated, procuring agencies are required to purchase it with the highest recovered material content level practicable.

³ The PowerPoint presentations can be found at <www.rmrc.unh.edu/partner.asp>.

25 recycled materials, the Dutch leaching methods and evaluation protocol related to the Dutch Building Materials Decree, and the activities of the European Union's CEN/TC 292 Committee⁴. That Committee is developing standardized protocols for scenario-specific evaluation of recycled materials uses.⁵

Dr. Heinrich Werner of the German Federal Highway Research Institute (BAST) provided a presentation on accelerated testing of recycled materials. Germany has the need for large quantities of materials for the increased construction underway in the former East Germany. This increased construction activity is also generating a significant amount of recycled materials. Dr. Werner discussed accelerated testing of pavements made with recycled materials. The work he presented was completed at the BAST accelerated testing facility using an impact loader to simulate truck traffic while road sections were subjected to various freeze/thaw cycles. The results were very performance-related and allowed them to make value judgments based on degradation, permeability, and rutting potential of the various materials. Most of the recycled materials (recycled asphalt pavement, construction and demolition aggregates) performed as well as natural aggregates. Conventional testing (triaxial compression) did not correctly predict performance.

Dr. Hans G. Johansson of the Swedish National Road and Transport Research Institute (VTI) presented a paper on the ALT-MAT Project (ALternative MATerials in Road Construction). The project was funded by the European Commission⁶ and was carried out by a consortium of nine organizations in seven countries. The objective was to develop test methods and evaluate field performance to assess the suitability of alternative materials in road construction, concentrating on unbound granular applications. The project activities were described and a tool kit of test methods for mechanical, leaching and hydrodynamic properties were presented. Case studies of the performance of alternative materials in roads showed that they give as good performance as natural reference materials and have not caused pollution of groundwater.

Other U.S. speakers included Dr. John Stutz and Ms. Rebecca Davio, TX DOT. Dr. Stutz of the Tellus Institute delivered a presentation entitled, "Applying Life-Cycle Thinking to Highway Materials." Dr. Stutz described the life-cycle approach and how it applies to highway materials. Life-cycle Thinking is more qualitative and considered less exhaustive than Life-cycle Analysis. Dr. Stutz supported the integration of recycling into the early project and product decision-making; considering alternative uses early can help generate lower overall costs.

⁴ CEN/TC 292 is the Committee European de Normalization that consists of seven working and three ad hoc groups harmonizing leaching and extraction tests.

⁵ This work is particularly important, as work done under NCHRP 25-09, "Environmental Impact of Construction and Repair Materials on Surface and Ground Waters," is of a similar nature. The NCHRP 25-09 work is about to be released.

⁶ The [European Union](#)--previously known as the European Community--is an institutional framework for the construction of a united Europe. It was created after World War II to unite the nations of Europe economically. Fifteen countries are members of the European Union, and some 370 million people share the common institutions and policies.

Ms. Rebecca Davio discussed the 7-step program for establishing successful DOT recycling programs. It includes (1) the need to think of recycled materials as a valuable resource, not as wastes; (2) ensure engineering and environmental quality in recycled materials; (3) use incentives rather than mandates to encourage recycled material use; (4) develop specifications that allow for recycled materials; (5) make as few procedural changes as possible to accommodate recycled materials; (6) publicize the program broadly; and (7) get started and make a difference.

The session closed with a panel discussion. The panel members were asked to comment on the adoption of closed material cycles⁷, on maximizing recycling by balancing economics, environment, and engineering, the role of public and private alliances to promote sustainability concepts and the possibility of any legislative initiatives to promote the cause. Members of the panel included:

- Doug Pitcock, Williams Bros., Associated General Contractors and the Association of Road and Transportation Builders of America
- Paul Wells, Chief Engineer, NY DOT
- Dale Thompson, MN Pollution Control Agency and Chair of the ASTSWMO Beneficial Use Task Force
- Jean Schwab, U.S. EPA
- Vince Schimmoller, FHWA
- Dave Newcomb, Vice President, Engineering, National Asphalt Pavement Association (NAPA)

Mr. Pitcock is the owner of one of the largest construction companies in the U.S. and has a strong background in recycling materials. He considers recycling of asphalt and concrete aggregate standard practice that supports his competitiveness, not simply profit.

Mr. Wells believes that the DOTs can act as change agents – being a catalyst for better use of recycled materials. While there is always pressure to use higher quality materials, performance-related specifications can really help the DOTs avoid direct material (method) specifications. He supported all types of partnerships to get this accomplished.

Mr. Thompson explained the ASTSWMO's Beneficial Use Report. A material is considered an industrial byproduct and not an industrial solid waste when it is shown that the material is being used or reused as an ingredient in an industrial process to make a product. He revisited earlier remarks about how difficult it is to make decisions across state lines and within each jurisdiction.

Ms. Schwab discussed EPA and its very limited role it has in this area. If it is designated as non-hazardous, the states and the local communities generally will be held responsible for disposal and use of the material. She believes that there is some possibility of incentive-based legislation. So far as incentive-based taxing, the EU countries generally own the landfills and are able to set social policy. In the U.S., most landfills are owned

⁷ A closed material cycle suggests that that all material introduced into a highway construction project may be beneficially reused at some later date.

by the private sector. If a higher value is placed on the material before it goes to the landfill, then it may go elsewhere.

All supported the general themes from the previous speakers. They all reemphasized that economics are extremely critical, as are incentive programs. Improving working relationships among the various disciplines will do much to improve the process.

This concluded the open sessions. The remaining workshop time was allocated to public sector officials.

III. Group Breakout Session Activities

The intent of breakout sessions was to provide an open environment where participants were encouraged to participate in focused discussions. The breakout sessions also served to achieve consensus on the primary concerns and issues that should be addressed. Finally, the breakout sessions provided diverse groups with an opportunity to build alliances and partnerships.

Overview of Workshop Activities

The second day of the workshop began with a brief preview of the day's schedule and a review of the previous day's accomplishments, key concerns and issues. Each participant came to the workshop with some preconceived notions on issues related to sustainable materials, sustainable development, and partnerships in the use of recycled materials in transportation. The focus of the morning session was to begin to close in on specific issues that affect participants and to begin to arrive at a prioritized list of the top issues that are shared by a majority of the participants.

To encourage open discussion, individuals from the audience were asked to respond informally to three questions:

- What do you do for a living, that is, what is your primary work function?
- What do you do in the recycling area?
- What recommendations would you make about recycling and future efforts?

The following sections summarize the key points:

Mr. Gerald Malasheskie, Penn DOT

Mr. Malasheskie is a state materials engineer. His previous work included materials research. He was also one of the participants in the 1999 European Scan Tour. Mr. Malasheskie explained that Pennsylvania has evaluated a wide variety of recycled materials. Penn DOT uses recycled asphalt pavement (RAP). He noted that the state does allow foundry sand, crushed concrete in base courses, and fly ash to address alkali-silica reaction (ASR) issues. He also noted that the Penn DOT is working to develop a plan for recycling, including legislative initiatives.

Mr. Malasheskie would like to see industry devote more research and development to the use of their own recycled materials. He believes that Penn DOT could increase the use of recycled glass and tires. He commented that in some cases, standards are already in place but not being used.

Mr. Kent Barnes, Montana DOT

Mr. Barnes is a state materials engineer. He noted that recycling is not a large industry in Montana and is generally limited to recycled asphalt pavement (RAP). He also noted that the state generates more RAP than it is able to use and has to give much of it away.

His major concern is the economics of recycling. In Montana, the counties pay for the road repair but generally lack resources to address recycled materials. He would like to hear about other approaches that would help address the economics issue.

Jeff Schmitt, NY DEC

Mr. Schmidt is a state environmental specialist responsible for the N.Y. State Department of Conservation Solid and Hazardous Materials Program. Since 1992, his agency has processed over 700 beneficial use permits.

Mr. Schmitt would like to see more integration with the DOTs, a better market development process, additional testing standards and improved consensus definitions.

Mr. Merritt Linzie, MN DOT

Mr. Linzie is the Director of the Office of Environmental Services at Minnesota DOT. His state has a cooperative program with other state agencies to minimize the purchase of products that produce waste. He cites a lack of communication and publicity on the state of the practice. As things stand, opportunities to cooperate are often missed.

Mr. Matt Frazer, IN DOT

Mr. Frazer is the part-time statewide recycling coordinator for Indiana DOT. Mr. Frazer's responsibilities vary from asbestos control to training and evaluation. He currently is involved in programs for shot waste, batteries, tires, hazardous waste, and foundry sand. Mr. Frazer noted that IN DOT uses RAP and recycled concrete for road base. IN DOT also has a reasonably aggressive program to use tires for fill material.

Mr. Frazer's primary concern is the lack of outlets for waste tires. Currently the state's high-volume use for tires is fill embankments. As its infrastructure demand for new construction diminishes, the state is looking for new high-volume outlets.

Mr. Charlie Pryor, National Aggregates Association

Mr. Pryor represents the aggregates industry. His activities include research, standards evaluation, and cooperation with federal agencies. Currently, the aggregates industry produces more than 150 billion tons per year of by-product fines. The industry is also seeing the transformation towards viable recycling economics.

Mr. Pryor explained that as an industry member, he many times is challenged by undocumented scientific claims. He would like to see more effective partnerships throughout the industry as a way of ensuring that proper scientific evidence is applied to the recycling process.

Mr. Haleem Tahir, AASHTO

Mr. Haleem explained that AASHTO serves the state DOTs, including DC and Puerto Rico. He noted that one area that works very well is the promotion of standards. AASHTO coordinates research through NCHRP and other agencies. He believes that states have made progress in the use of recycled materials. Almost 80% of RAP is used today. The use of recycled glass is growing, as well as high- and low-quality fly ash, ground slag, crushed concrete, tires, and flowable slurries.

Mr. Tahir believes, however, that continued progress will require a significant cultural change. Engineers are by training cautious and slow to change. He believes that the engineers need to work more closely with the scientists to understand their different needs. He also believes that more effort needs to be focused on demonstration and high-profile projects with industry partners, including the publication and promotion of success stories.

Mr. Walter "Butch" Waidelich, FHWA

Mr. Waidelich is a FHWA Division Administrator in New Hampshire. He explained that he works with the state in providing assistance in allocating federal resources. Mr. Waidelich seeks out opportunities to implement programs on innovative materials. He is on the Advisory Board for the RMRC.

He believes that his division could be more proactive in the development of new specifications. Mr. Waidelich often hears comments from others questioning why recycled materials should be used at all. Many often express concern about the health and safety aspects of unknown materials. Much of this concern, he believes, could be diminished by more communication. He noted that even with specifications, if those charged with implementing them do not trust them, little would be accomplished.

Mr. Dale Thompson, ATSWMO

Mr. Thompson explained that ATSWMO has committees, subcommittees, and task forces that address Superfund, solid waste, pollution prevention, and other program areas. Primarily ATSWMO works on policy and information exchange between states. He also stated that ATSWMO works with U.S. EPA works to develop solid waste policies. The current focus is on foundry sand.

Mr. Thompson stated that it is very difficult to standardize a policy across state lines. The perception of risk and threat to human health is a large issue. Some advocate zero tolerance for recycled materials; others demand one hundred percent reuse. This debate frequently puts the recycled industry in the middle. In addition, the industry itself brings different perspectives to the table. Within this environment, ATSWMO works to build partnerships.

Mr. Byron Lord, FHWA Office of Pavement Technology

Mr. Lord explained that he has a wide variety of responsibilities in the pavement and materials area. He noted that he sees his job as building partnerships. This includes innovation of new technology, promotion, bridge building, research facilitation, and mentoring. Mr. Lord's office attempts to identify and improve the functionality of materials in the highway environment. He also has the responsibility to develop the FHWA's reauthorization legislation in this area. He also represents the FHWA on the Rubber Pavements Association board. He too noted that little more could be done without improving partnerships.

All attendees were then invited to make additional observations.

Management and Coordination Issues

- Senior management generally are not involved in current recycling issues; there are no "tipping point" issues. This requires significant uphill promotion of any creative recycling initiatives. The "view from the middle" (managers) suggests that without a cultural change at the top, it will be very difficult to address the new partnerships and risk-taking that would lead to increased use of recycled materials.
- Even with new partnerships, providers and users will need to build mutual trust. The private sector, specifically, needs to take the initiative and foster better partnerships.
- Even though a recycled material has an engineering specification, has been extensively tested and may even be superior to virgin materials, it still may not be used in everyday applications.
- The private sector recycling industry does not seem to be doing enough advanced R&D work prior to introducing their products to the highway community.
- The private sector recycling industry is hampered by the need to create new initiatives every time they cross state lines.
- Coordination is difficult when the "zero-tolerance" and "use-it-all" recycling camps are so fixed in their positions.
- Even if public agencies do extensive work on a recycled material, they still have to promote the product to cities and counties. Many times the cities and counties do not have the technical knowledge or financial resources to apply the materials.
- Based on the way programs are managed today, some feel we may actually be reducing the opportunities for recycled materials.

Technical Concerns

- There is an urgent need for coordinated standards for the use of recycled products and materials, especially standards that have been agreed upon by environmental specialists and engineers. Standardization should also include consistent evaluation techniques and faster test procedures.
- There is a strong need for more performance-based specifications in lieu of method or material specifications.
- There is frequent misunderstanding among parties. A common dictionary of terms would be extremely beneficial to all sides.
- Waste-tire programs continue to suffer from the lack of technology coordination.

- There is little if any integrated technology training for the various disciplines.

Information Concerns

- There is no easy way to transfer information and technology across state lines.
- Waste-tire programs efforts are not shared.
- There is limited publicity on positive recycling efforts.
- There is a major misconception that if its recycled, it has to be cheaper than virgin material.
- There is no “committed-to-heart” reason why the highway recycling effort is important.

After this general session, the participants were organized into separate groups, based primarily on whether they work at the *national* or *state* level. The concerns from the previous session were rearranged into seven primary categories. Each of the two groups was asked to further discuss issues in the following seven categories and reach consensus on a common agenda. The following list summarizes the seven primary categories of concern.

1. Technology and Information Sharing
2. Lack of Standards--General specifications, performance-based specifications, and testing speed
3. Training
4. Senior Management Leadership
5. Market Identification and Development
6. Perception Issues
7. Financial resources

Both groups engaged in open discussion on each of the seven categories. There was overall agreement that “waste-to-use” of recycled materials is very complicated. Generally, a waste material must first meet environmental safety issues, followed by engineering economics and standards. The waste producers normally work with the state EPA to determine environmental acceptance. The producers are then basically on their own to find product markets and determine the economic and engineering expectations. While many states do have beneficial use programs, it is fair to say they are generally minimally staffed and reactive, not proactive.

If waste producers seek entry into the highway market, then they will need to present organized product material and engineering properties to highway engineers. Many times highway engineers will not be familiar with the waste product specifics, the previous environmental decisions, the product properties, the volume of available product or its variability. Unfortunately, few state DOTs have set up pro-active cooperative programs.

Conversely, many producers have little knowledge of or experience with highway materials, the testing and acceptance process, the economics, and the decision making process between the state and the contractor. Herein is the heart of the management problem.

IV. Field Trip

The afternoon of the second day of the workshop included a field trip to two private firms that are active in producing recycled materials for the Houston area. The intent was to provide examples of successes in partnering and participation in sustainable development. The two firms were a concrete recycling plant and a large organic composting facility.

The first firm, Big City Crushed Concrete, produces a line of recycled products for both public and private consumption. In Houston, coarse aggregate for concrete construction is not locally available. This firm is able to provide the recycled material at a price comparable to or less expensive than the next available alternative of acquiring coarse aggregate from outside sources. This firm also benefits the city by recycling concrete that would otherwise contribute to landfill congestion.

The second firm is a Houston area composting facility Living Earth Technology Company. Similarly, this firm collects and processes many forms of landscape waste that would otherwise be added to local landfills. These organic materials, including grass, leaves, trees, and select byproducts from factories (such as rice hulls) are composted into a variety of products, each with a unique composition and size gradation for different applications. Similar to the crushed concrete facility, this firm collects raw materials from the City of Houston, and in turn sells much of its finished products back to the city.

The key to the success of these efforts was the active participation of the TX DOT recycling coordinators. The TX DOT made simple changes to their specifications that allowed the use of recycled concrete. The industries credited this coordination factor as the key to market and product development.

V. Summary Session

In the closing session, the two groups presented their key findings and recommendations. The recommendations were very similar and have been combined into one major list.

National Coordination and Partnerships

National organizations such as the EPA, FHWA, AASHTO, ASTSWMO, the Department of Energy, and others should meet on a regular basis to discuss mutual recycling issues, since each has a specific responsibility and interest in sustainability of recycled material usage in the highway facility. The attendees recommended that the leadership of these organizations initiate such meetings, establish a common agenda, and begin to provide an integrated, cooperative, and continuous effort through a national steering committee.

The mission of the group would be to establish more formal common interests and ensure that there is an understanding of each other's responsibilities and requirements. At a minimum, the agenda should address the issues discussed at this workshop.

The general perception is that the highway industry has taken more initiative than the environmental sector. The proposed steering committee should encourage the environmental side to increase participation/leadership.

Many attendees believe that if the agencies could show better cooperation, then it would be an incentive to various legislations not to issue mandates.

State Coordination and Partnerships

Many states do not now have formal contact between their DOTs and EPAs. It is suggested that each state jointly consider formalizing a relationship to address common issues. Many of the state EPA specialists consider the highway environment as one of the most important markets for recycled materials yet do not regularly seek out the state DOTs for input or coordination.

It was also suggested that each organization formally name a recycling coordinator within both the state DOT and the state EPA. If possible, the position should be a full-time job; as a minimum, the liaison should be the access point between the two agencies. This would also provide an excellent and effective vehicle for industry.

Each state could benefit from a formal coordinating group. It was also recommended that such a group include key local and county authorities.

Technology, Standards and Specifications

Recommendations:

- Get a working understanding of the European policy models, along with a better understanding of the engineering and leachate evaluation efforts
- Review and understand existing federal and state standards, but do it cooperatively

Both environmental and engineering standards vary from state to state. Many engineering standards initiate with material description. Nearly all attendees saw the eventual need for using performance-related specifications. It was agreed that for specific recycled material products, it would be possible to develop common guidelines. It was also thought that environmental standards could be developed jointly.

The traditional belief that recycled materials must meet the same standards as virgin materials in many cases eliminates them from use, even though they may potentially perform well in service. The highway community is moving towards performance-related

specifications; however, it is a complicated program and will evolve over time. Another concern is the time and expense of testing.

In the interim, it would be an improvement if there were some sharing of common testing protocols, evaluation procedures, and other standards that could be used by other interested parties. They would also include leaching protocols, LCAs, etc.

Another possible issue is to identify or categorize projects and products so that others may share the list. The ASTWSMO Beneficial Use Report would be a good start. FHWA and AASHTO's NCHRP have produced research reports that focus on key material properties. They could be used to help organize such a control list.

The participants also suggested that a common research agenda could be developed that addressed both the environmental and engineering properties of recycled materials. The research agenda could also be coordinated through a university. It was thought that the RMRC would be a logical place for this to happen. It would also be beneficial to include key international research. Many public agency participants also wanted to see more research conducted by waste producers. There was no attempt to identify funding sources, however.

Marketing, Communication, and Information Sharing

Any marketing initiative must first tackle the misconceptions that plague the recycling industry. They are:

- Recycled materials **MUST** be cheaper than virgin materials
- Recycled materials **MUST** meet the same specifications as virgin material
- Recycling technology changes at state borders
- Recycling is pretty well underway and needs no further management
- Recycling specialists in the highway sector and the environmental sector must be in conflict -- it is the nature of the business

There was general agreement among participants that a common theme and consistent message needs to be developed if a new partnership is to happen. It is important that this message be carried to senior management.

The participants could not identify many positive examples of information sharing other than the RMRC. The needs include technology sharing, key regulatory or legislative initiatives, project activities, and standards availability. They strongly recommended the following:

- Develop a formal integrated information network for both highway engineers and environmental specialists. The network should include the private sector and key international contacts as well. Consider building the information network with the RMRC, now under contract with the FHWA.
- Develop and share coordinated fact sheets on specific materials.

- Develop workshop and conference agendas that address the needs of both the engineering and environmental community. Make sure that industry is invited.
- Conduct and publicize demonstration and pilot projects on key products.
- Establish a point of contact in both DOT and Environmental agencies – preferably as a full time job – and initiate a strong cooperative effort.

Many of the participants recommend using demonstration projects for new products and uses. They are very effective tools in promoting possible uses of materials and for linking the community together.

All Internet and electronic media should be considered to keep people connected and informed.

It was also recommended that the marketing effort include the legislative branch by asking for sponsorship of national recycling demonstration projects. These projects would be used to bring all the various entities together in a spirit of cooperation and technology sharing.

Markets

It was not very clear exactly where market development responsibilities rest. Most look to the industry. Some state EPAs have a formal mission to assist industry in locating markets. Generally, however, most agreed on the following points:

- The industry itself does not always have good numbers on the material volume or variability. In addition, the industry sometimes does not do enough to evaluate the material as an engineered product for highway use.
- The State EPAs independently do not have a full understanding of the potential in the highway market.
- The State DOTs do not always understand the environmental issues behind the product nor do they have the financial, technical or time resources to fully digest the history behind these new products.

Planning

Several participants proposed that the Environmental Impact Statement required for large projects consider material usage and demands. This would allow for early consideration of recycling. It would include materials within the highway limits, their reuse in the project, and their potential removal off-site early in the project life. It would also include reusable material sources within economic transportation of the project site.

It was also proposed the materials usage be considered in an even wider time frame, possible in a systems planning mode—a more complete materials recycling plan.

Training and Education

Currently there are no known joint-training programs for highway engineers or environmental specialists. DOTs rely heavily on either National Highway Institute (NHI) training or in-house training. Most environmental specialists looked to EPA training courses, although these courses do not address the engineering properties.

It was recommended that integrated training be considered that is mutually beneficial to both highway and environmental specialists. It would start with the identification of training needs, develop options, define audience, and outline a program. This could be done within the existing framework of FHWA's NHI, EPA's training, or a university program like the RMRC.

Closing Panel Discussion

Upon completion of both the state and national groups' presentations, the workshop concluded with the reconvening of several of the panel member. Their closing thoughts are summarized below:

Comments from Dr. Taylor Eighmy, Director, Recycled Materials Resource Center

Dr. Eighmy spoke about how the RMRC is currently addressing many of the raised action items through its research and outreach mission. One additional area of activity might be in the area of training individuals who could then serve as trainers for the National Highway Institute, AASHTO, ASTSWMO, etc.

Comments from Ms. Shari Schaftlein, Deputy Director, Environmental Services, WA DOT

Ms. Schaftlein was very positive towards the recommendations. She explained that the many State environmental officers are extremely busy with managing the NEPA issues. She stated that her goal would be to create more positions of dedicated coordinators in more state DOTs. She believes the AASHTO Standing Committee on the Environment could be a messenger to the DOT chief executives. She also stated there is a need to create greater involvement from state EPAs.

Comments from Ms. Katherine Holtz, Director, Materials Section, TX DOT

Ms. Holtz supports an approach that links national specifications and test methods for both the highway and environmental communities. She noted that Dr. Eighmy has already surveyed the U.S. to prioritize the development of specification for recycled materials. She concluded that her primary task would be to see if the SOM could work with the SOE and with ASTSWMO to put it all together.

Comments from Mr. Byron Lord, Implementation Director, FHWA

Mr. Lord stated that his primary task now is to determine how to carry on the partnerships that were initiated at the workshop, and make them self-sustaining. He noted that nearly every item in the list will require a higher, more visible profile and with strong leadership.

Comments from Mr. Dale Thompson, ASTSWMO Beneficial Use Committee

Mr. Thompson agreed with Ms. Shaftlein's comments. He stated that his responsibility at this point is to take these conclusions back to ASTSWMO and show that these are opportunities to be seized.

Comments from Ms. Jean Schwab, Office of Solid Waste, EPA

Ms. Schwab said that she would like to work with Dr. Eighmy and his team to promote collaborate efforts. She stated that she would also like to work more closely with Mr. Lord to provide support at the national level. She believes that state DOTs connecting state EPAs is a great beginning.

In addition, the presenters from Europe thanked the participants and complimented them for the high level of cooperation they demonstrated.

VII. Conclusion

The business of using recycled materials to foster sustainable development in the transportation industry requires an orchestration of professions and organizational entities. Often, the solution is described as partnerships, but the solution must venture much deeper than cultivating casual relationships and one-time meetings. Even the types of partnerships recommended in this workshop are subject to a wide variety of conditions. The private sector must partner with the public sector. The transportation agencies must partner with the environmental agencies. Each of these partners has their own sets of needs and criteria for measurement and evaluation. Sometimes this results in competing objectives. Shared terms, standards, tests, and innovative technologies must be created. Channels of communication and broadcasting must be enhanced and established.

All the participants of this workshop intersect at a shared goal – ultimately to cultivate the use of recycled materials in transportation. The participants took the first step in taking inventory of what the needs are of the decision-makers and stakeholders in this industry. The next step is for senior leadership in the key organizations identified in the report to assemble, define their overall goals and strategies, and identify the partnering structures they will support for the future.

Appendices

Note: Appendices 1 and 2 are attached. The rest are posted on the web - www.rmrc.unh.edu under Sustainability.

1. Agenda
2. Summary of Scan Trip
3. “Life Cycle Assessment of Civil Infrastructure Systems” by Dr. Arpad Horvath, University of California at Berkeley
4. “National View” by Dr. Taylor Eighmy, Recycled Materials Resource Center
5. “Dutch Sustainability Initiative” by Dr. Jan van der Zwan, Ministry of Transport, Public Works, and Water Management in the Netherlands
6. “DOT Recycling: Seven Steps” by Ms. Rebecca Davio, TX DOT
7. “European C&D Recycling, Mr. Kartsen Ludvigens, RGS 90, Denmark
8. “Applying Life-Cycle Thinking to Highway Materials” Dr. John Stutz, Tellus Institute
9. “European Leaching Protocols” by Dr. Hans van der Sloot, Netherlands Energy Research Foundation (ECN)
10. Accelerated Testing in Germany, Dr. Heinrich Werner, German Federal highway research Institute
11. “Alt Mat Research” by Dr. Hans G. Johansson, Swedish National Road and Transport Research Institutes

**Partnerships for Sustainability
“A New Approach to Highway Materials”
General Session**

**Houston, Texas
Westin/Galleria
October 9-11, 2000**

Mission

This workshop follows upon a successful Federal Highway Administration Technology Scanning Tour of Europe in September 1999. The purpose of the Scan was to explore European advances in recycling in the highway environment. The Scan Team was so impressed with what they saw and heard on the tour that they helped organize this workshop so that more people in the US could benefit from this information.

The first day of the workshop is tailored to knowledge sharing. The second and third days are specifically directed to Federal and State DOT and EPA materials engineers and environmental staffs to 1) find common ground and 2) to encourage working together on all aspects of recycled materials use within the highway environment.

Monday, October 9

8:00 AM Welcome, Hosted by Texas Department of Transportation
 Ms. Katherine Holtz, Director, Materials Section

- Mr. Vince Schimmoller, Program Manager, Department of Transportation, Federal Highway Administration, Infrastructure Core Business Unit
- Ms. Jean Schwab, Environmental Protection Agency, Solid Waste Division –, Municipal Information and Analysis Branch, Solid; Municipal and Industrial Solid Waste Division
- E. Dean Carlson, American Association of State Highway and Transportation Officials, Secretary of Transportation, Kansas DOT

8:30 AM Keynote Presentation - "Life Cycle Assessment of Civil Infrastructure Systems" by Doctor Arpad Horvath, Assistant Professor, Department of Civil and Environmental Engineering, University of California at Berkeley

While sustainable development and better environmental quality are becoming important social goals, their analysis and implementation are complicate by a myriad of technical, economic, environmental and organizational factors that require interdisciplinary approaches and private and public partnerships. Life-cycle assessment is emerging as the most promising approach to such an analysis, from the material extraction phase through the end-of-life phase. As the economic and

environmental implications of construction, operating, and decommissioning of civil infrastructure systems are significant, environmental issues must be seriously considered. Dr. Horvath will present the state-of-the-art in life-cycle analysis and provide real life examples.

Overview Theme

**9:00 AM "National View" by Taylor Eighmy
Recycle Materials Resource Center**

Dr. Eighmy will speak about (i) trends in recycling in the U.S. highway environment, (ii) recent FHWA and NCHRP research projects related to recycling, (iii) recent U.S. EPA and Environmental Council of States activities, (iv) the recently completed Association of State and Territorial Solid Waste Management Officials beneficial use survey, and (v) the Recycled Materials Resource Center outreach and research activities.

**9:40 AM "Dutch Sustainability Initiative" by Dr. Jan van der Zwan
The Netherlands Public Works Agency**

Dr. van der Zwan will talk about the Dutch Sustainability initiative, the role of CROW in setting standards, and general Dutch successes in recycling in the highway environment.

10:30 AM Break

**10:45 AM "DOT Recycling: 7 Steps" by Rebecca Davio
TX DOT**

Ms. Davio will provide tips on how to start a DOT recycling program encouraging the use of recycled materials in road construction and maintenance projects. Her presentation will draw on 5 years experience by the Texas Department of Transportation.

Economic Theme

**11:15 AM "European C&D Recycling" by Mr. Karsten Ludvigsen
RGS 90, Denmark**

Mr. Ludvigsen will talk about the role of legislation in promoting recycled materials uses and the successes of the RGS 90 company in acting as a collector, processor, and distributor of recycled materials used in Danish highway construction; particularly about the use of high quality C&D aggregates.

**11:55 AM "Applying Life-Cycle Thinking To Highway Materials"
by Dr. John Stutz, Tellus Institute**

Dr. Stutz will begin by describing the life-cycle approach and how it applies to highway materials. He will discuss the logistics and

economics of recycling highway materials, from the waste generators' and recyclers' perspective. He will also discuss opportunities for the use of other recovered materials, such as compost. Policies that would harmonize construction practice with the solid waste management hierarchy will receive particular attention.

12:30 PM Lunch

Environmental Theme

1:30 PM "European Leaching Protocols" by Dr. Hans van der Sloot
Netherlands Energy Research Foundation

Dr. van der Sloot will talk about the ECN (Dutch) leaching database (on 25 recycled materials), the Dutch leaching methods and evaluation protocol related to the Dutch Building Materials Decree, and the activities of the European Union's CEN TC 292 Committee that is developing protocols for scenario-specific evaluation of recycled materials uses.

2:30 PM Break

Engineering Theme

3:00 pm "Accelerated Testing in Germany" by Dr. Heinrich Werner, Dipl. Ing.
German Federal Highway Research Institute

Dr. Werner will talk about accelerated testing of pavements made with recycled materials. The work was done at BAST in their accelerated testing facility using an impact loader to emulate truck traffic while road sections were subjected to various freeze/thaw cycles.

3:40 PM "Alt Mat Research" by Dr. Hans G. Johansson, Swedish National
Road and Transport Research Institute

"Dr. Johansson will present the findings of a European Commission Fourth Framework collaborative research project on alternative materials in the highway environment. Research from six countries on seven different types of recycled materials will be highlighted.

4:15 PM Break

4:30 PM Policy Panel "New Approaches to Recycling Materials"
Moderator, Shari Shafflein, Washington DOT

ARTBA/AGC Doug Pitcock, Williams Bros., AGC/ARTBA
AASHTO Paul Wells, Chief Engineer, NY DOT

ASTSWMO Dale Thompson, MN Pollution Control Agency and Chair of
ASTSWMO Beneficial Use Task Force
EPA Jean Schwab, EPA
FHWA Vince Schimmoller, FHWA
NAPA Dave Newcomb, Vice President, Engineering, National
Asphalt Pavement Association

The panel will be asked to comment on the adoption of closed material cycles, on maximizing recycling by balancing economics, environment, and engineering, the role of public and private alliances to promote sustainability concepts and the possibility of any legislative initiatives to promote the cause.

5:15 PM Workshop Instructions

5:30 PM Reception

Partnerships for Sustainability A New Approach to Highway Materials

Workshop Sessions

Vision

The highway materials and solid waste communities are working together on a common agenda to satisfy the sustainable needs of future generations.

Specific Goals of the Workshop Portion

- Better understand of each other's organizational roles and responsibilities in the environmental arena.
- Establish the beginnings of a working arrangement for the future.

Objectives

- Understand each segment of the Highway Materials - Environmental relationship
- Understand terms such as "highway materials, beneficial use, and sustainability" as they relate to each other's current work effort.
- Define "partnerships" that would help fulfill our vision
 - Three levels - national, state, association

Tuesday October 10

AM Session

8:00 am “What do you do for a living?”

Ferragut, Moderator

During this session, selected attendees will discuss what they do for a living. What kind of everyday issues they face, what limitations they have, what technology gaps they face of key issues, and what political/social pressures dictate the pace of environmental life in their organization. We will also share different unique partnerships that have been established

We will start with VERY BRIEF Presentations by DOT Materials Engineers, State DOT Environmental Engineers, State Environmental Engineers, Association Managers, FHWA, and EPA, followed by an open discussion

10:00 am Breakout Sessions

We will break into smaller groups. One group will consist of national representatives from EPA, FHWA, and the Associations with a few state representatives. The other group will consist of state representatives will address issues pertaining to HIGHWAY MATERIALS and INDUSTRY BY-PRODUCTS, PARTNERSHIPS, and SUSTAINABILITY. Each group will have a list of feeder questions.

12:00 noon Box Lunch and Field Trip – Sponsored by the AGC of Texas

6:30 PM Dinner Sponsored by Rubber Pavements Association

Wednesday October 11

AM Session

07:30 am Breakout Sessions (continued)

We should finish what we started yesterday morning. Look for some adjustments to this schedule based on the progress we showed the previous day.

09:00 am Summary Team Formation

Two representatives from each group will meet to organize a presentation to the general session. The others? We will be asking the individual state teams to meet and to pull together summary thoughts on the past two days and present different

items on how they may work together better to promote environmental issues within the state borders.

10:30 am Presentation and Round Table Discussion

Leaders will make the formal presentation and then have an open session for discussion. We will then hear from the different state delegations.

11:30 am Closing

We will discuss the final report, when it should be ready for review and comment, and how we should distribute it. Then expect a little motivation, pep talk.

12:00 noon Adjourn

Appendix 2.

**Summary of FHWA International Technology Scanning Program
For
Recycled Materials Use in Highway Environments: Uses, Technologies and Policies**

BACKGROUND

The use of recycled materials in the highway environment has been occurring with varying degrees of success in the United States for the last 20 years; notably with recycled asphalt pavement (RAP), reclaimed concrete pavement, coal fly ash and blast furnace slag. The U.S. Congress, in the 1998 Transportation Equity Act for the 21st Century (TEA-21), established the Recycled Materials Resource Center (RMRC) at the University of New Hampshire (UNH) to use research and outreach to reduce barriers to recycling in the highway environment. Congress also stipulated that recycled materials be researched to improve the durability of the surface transportation infrastructure. A number of states (e.g., Pennsylvania) and local governments have passed legislation to promote recycling in road construction. The private sector is developing innovations in processing and applications. Some states have beneficial use determination processes (BUDs) to evaluate uses; however, there is not uniformity among states. State Departments of Transportation (DOTs) and state environmental protection agencies (state EPAs) are trying to balance the desire for increased use of recycled materials with concerns about potential environmental impacts. There is an increasing interest within the highway community at all levels to learn more about advances in the use of recycled materials in the highway environment and how it relates to sustainability initiatives within the transportation sector.

OBJECTIVES AND PANEL COMPOSITION

The objective of this scanning tour was to review and document innovative policies, programs and techniques in Europe. Recommendations would be made that would lead to the reduction of barriers to recycled material use. Sweden, Denmark, Germany, the Netherlands and France were identified as nations that have active research, policies and programs promoting the reuse of recycled materials in the highway environment. The U.S. delegation met with over 100 representatives from transportation and environmental ministries, research organizations, contractors, and producers involved with recycled materials in the five countries.

The U.S. delegation was assembled under the Federal Highway Administration's (FHWA) International Technology Scanning Program. The panel was sponsored by FHWA, the American Association of State Highway and Transportation Officials (AASHTO) through the National Cooperative Highway Research Program (NCHRP), and the RMRC at UNH. The panel included members with expertise in materials, pavement engineering, pavement construction and recycling, beneficial use determinations, and environmental evaluation. They represented FHWA, U.S. EPA, state

DOTs, the American Public Works Association (APWA), the National Asphalt Pavement Association (NAPA), and academia.

GENERAL CONCLUSIONS

Recycling for Sustainable Road Construction: All the countries that were visited had recycling policies specifically or generally promoting sustainability. There is also a pervasive public culture about recycling and social democracy that promotes national behavior change. In many of the countries, there is an effective stakeholder consensus process that is used for developing engineering and environmental specifications. There are a wide variety of drivers that influence recycling success from national values to practical considerations at the regional level. Some of these drivers are: a lack of virgin material, public opposition to aggregate mining, high transportation costs, opposition to landfilling, and high population densities. In areas of the U.S. where similar drivers are present, European experiences may be transferred. In the Netherlands, the Dutch have a formal policy for sustainable development in highway construction that embraces the use of recycled materials. There is public opposition to landfills and excavation of natural materials. The government has a policy that minimizes the use of natural materials and promotes the use of recycled materials within a market system. The government cooperates with industry by sharing risk and profit and providing unambiguous technical and environmental standards. High degrees of recycling are seen, especially for construction & demolition (C&D) aggregates, blast furnace slags, recycled asphalt pavements (RAP), coal fly ashes, steel slags, and municipal solid waste incineration bottom ash. The government has helped to start companies specialized in the marketing of lightly contaminated soils for use in sound barriers adjacent to highways, fills and embankments. The success seen in the Netherlands is related to advances in all aspects of the sustainability model: a robust market, clear policy, economy, appropriate technical and environmental standards, and innovative technical processes that involve the private sector. The Dutch sustainability model has elements that should be considered in the U.S. transportation community's overall goals for transportation sustainability.

Economics: Engineering and environmental life cycle costs and benefits are the basis for many of the recycling initiatives in Europe. The free market generally plays a central role in all aspects of the highway recycling industry. Where this is not the case, government acts as a catalyst to establish a market. Tax structures (both incentives and disincentives) have played a large role in promoting recycling in the highway environment in Denmark, the Netherlands, and Sweden. There are taxes on the use of natural materials in Denmark and in the Netherlands. Restrictive landfill taxes and policies in the Netherlands, Denmark and France are also promoting recycling; in these countries, the landfills are frequently government owned. A pending European Union (EU) landfill directive for 2002 designed to limit the landfilling of inert materials also is influencing recycled material flow; many contractors in the five countries are positioning themselves to use more recycled materials. A number of materials like RAP, blast furnace slag, crushed concrete, and high quality C&D aggregates are of high engineering and environmental quality and compete favorably with natural materials. Demand for some of these materials in the Netherlands is so high that there are anticipated shortages. Engineering

and, in some cases, environmental warranties reduce government or owner liability and are widely used and provide flexibility for the greater use of recycled materials. These warranties also drive innovative public sector research. There were widespread sentiments expressed in many of the countries that recycled materials should be evaluated on their technical merits for their highest possible use and not because of direct governmental mandates.

Engineering: Recycling is generally encouraged at the national level by transportation ministries who provide standardization, specialized testing, and performance evaluation. A number of countries require that recycled materials meet the same specifications as natural materials and provide equal performance. An approved product list is generally not used in the host countries, but rather ultimate performance is more a driver to promote recycled materials use. There is a general sense that recycled materials should be used in an application to return the highest possible value. As in the U.S., there is still concern that many engineering test methods do not predict true field performance, though ongoing research in Germany and Sweden with load simulators is addressing this. In the Netherlands, an innovative, Swiss-designed double drum hot-mix plant capable of recycling up to 70% RAP was observed. Companies that supply natural materials also supply recycled materials. Many countries utilize technical and environmental quality assurance/quality control (QA/QC) programs so the recycled materials have the same level of quality as natural materials. Frequently, the material processor or supplier is the certifying organization.

Environment: Recycling at the national level is accomplished by environmental ministries who develop laws and compliance structure. National environmental research laboratories are providing test methods and approaches to evaluate environmental performance and assist in setting standards. Implementation and regulation are occurring at the regional and local level. There is consistent agreement to move from laboratory work to performance modeling based on field validation. An EU 4th Framework Program project called Alternative Materials (ALT MAT) illustrates this approach and is a model for U.S. consideration. In the Netherlands, an environmental approval process is used that involves mechanistic leaching tests and application-specific evaluation of incremental impacts to background soils and groundwater. A large leaching database is also maintained at the Netherlands Energy Research Foundation. Within the EU, there are efforts toward standardizing an approach to evaluate the environmental performance of products, including highway materials. Lessons have also been learned from isolated examples of environmental problems created from storage, processing, transport or use of some materials. In some cases, public awareness and education efforts have been needed to overcome perceived environmental risks.

FINDINGS AND RECOMMENDATIONS

In the European countries that were visited, recycling occurs when it is economic to do so. Factors in the market place dominate, but are generally supported by government policies and regulations such as bans on landfilling, landfill taxes, and natural aggregate taxes. Generally, clear and unambiguous engineering and environmental test methods and

performance standards help to reduce uncertainty and allow recycled materials to compete with natural materials. Where tests and standards do not exist, governments often support recycling by sharing risk.

This is somewhat contrasted with the U.S. situation. Some recycled materials like RAP, coal fly ash and blast furnace slag are widely used in a true free market situation because of their excellent performance and competitive costs. Other materials (e.g. foundry sands, steel slags) are used more locally in response to more specific local market forces. There is little federal government involvement, except for construction procurement guidelines for materials like coal fly ash. Rather, the situation is driven at the state level. For example, the State of Pennsylvania has adopted legislation to promote recycling in the highway environment. However, there is a wide range of engineering and environmental approaches to BUDs by the states. California, Illinois, Massachusetts, New Jersey and Pennsylvania are working to standardize the BUD process and create reciprocity. There are wide spread needs for clear engineering and environmental test methods and performance standards. The owner or contractor generally assumes risk. The states, academia and the private sector are conducting significant research.

Table 1 provides a summary of specific findings and corresponding recommendations for the U.S. situation. The final report will contain a more complete discussion and additional recommendations. The U.S. delegation will provide leadership in sharing these recommendations at a national level with their various constituencies. Tentative assignments to act on recommendations have been made in the table. The delegation believes it is particularly important to adopt aspects of the Dutch sustainability model as a means to promote recycling in the highway environment; this will be detailed further in the final report. Further implementation strategies for the U.S. delegation will include electronic and written distribution of the final report, presentations, published articles, and development of a web site.

Table 1: Summary of Findings and Recommendations

Subject	Findings	Recommendations [Lead Organization From Scanning Team to Act on Recommendation]
<p>Recycling for Sustainable Road Construction</p>	<p>The Dutch sustainability policy is centered on a <i>market system</i> where both <i>policy</i> and <i>economy</i> influence the market. There are clear and unambiguous <i>technical and environmental standards</i>. The government promotes recycling by using <i>taxes</i> as incentives or disincentives and by <i>assisting</i> start up companies. <i>Technical processes</i> are developed to assist in providing quality material.</p> <p>A high degree of <i>information</i> and <i>technology transfer</i> was seen within various ministries and agencies within each country as well as between countries. The EU 4th Framework Program project “Alternative Materials” (<i>ALTMAT</i>) Project is one such example of cooperation and technology transfer.</p> <p>There is a high degree of <i>public awareness</i> in Europe about recycling. Federal and local governments have excellent <i>informational campaigns</i>. There can still be concern at the public level. Non-governmental organizations (NGOs) are involved in policy development in the Netherlands.</p>	<ul style="list-style-type: none"> - Include a recycling strategy in the sustainability aspect of FHWA’s and AASHTO’s strategic plans and long-range research priorities [FHWA, AASHTO SCOE]. - Create a framework for state DOTs to consider the use of recycled materials in project planning, alternatives analysis, and mitigation analysis [AASHTO SCOE, SOM]. - Encourage state DOTs to conduct long-term materials supply plans and recycled materials availability plans [AASHTO SOM]. - Develop clear engineering and environmental guidelines at the state and Federal level that are available for suppliers and decision-makers [RMRC]. - Prepare a briefing document for the U.S. Congress and state legislatures [FHWA, RMRC]. - Prepare a briefing document for environmental foundations [RMRC]. - With the new FHWA-EU partnership negotiated under the EU 5th Framework Program, explore research coordination, technology transfer, and exchange of experts [FHWA, AASHTO, ASTSWMO, RMRC]. - Hold a special TRB session on recycling in the highway environment [RMRC, FHWA, AASHTO, NAPA]. - Develop a National Highway Institute course on recycling [RMRC]. - Conduct a public awareness program [AASHTO, FHWA].
<p>Economics</p>	<p>Recycling successes in the Netherlands, Denmark and France are based in part on <i>market opportunities</i> for materials suppliers and contractors. Life cycle costs</p>	<ul style="list-style-type: none"> - Encourage contractors to use their private markets as a place to innovate and develop technologies [NAPA]. - Adapt current FHWA LCA procedures to include recycled materials; it should address environmental costs [FHWA, RMRC].

Subject	Findings	Recommendations [Lead Organization From Scanning Team to Act on Recommendation]
	analyses (LCA), some using <i>environmental costs</i> , are used.	
Engineering	<p>A number of countries are moving towards <i>performance based design procedures</i> and to <i>accelerated testing</i> to predict material performance. However, there is still concern that <i>test methods do not predict true field performance</i>.</p> <p>A number of advances were observed in the (i) use of <i>foam bitumen</i> as a stabilizing agent for recycled materials used in sub-base and base course, (ii) <i>hot recycling of RAP</i> in a double drum system, and (iii) the use of <i>C&D aggregates</i>.</p>	<ul style="list-style-type: none"> - Conduct recycling demonstration projects about foam bitumen, hot recycling, C&D aggregate use [FHWA, AASHTO, NAPA, RMRC]. - Encourage AASHTO and state DOTs to involve contractors more in committees establishing specifications [AASHTO]. - Evaluate contractors with respect to use of recycled materials or environmental protection during contract performance reviews [AASHTO]. - Develop and implement the use of warranty and performance based specifications.
Environment	<p>The Netherlands uses a hierarchy of <i>mechanistic leaching tests</i> of both recycled materials and their highway products to look at cumulative release of constituents and their marginal impacts to soils and ground water. This is also generally the basis for an EU normalization activity to adopt this approach.</p> <p>Efforts are underway to create a European <i>database on product leaching</i>.</p> <p>Innovations are occurring in France on the use of <i>tires and plastics</i> in appurtenances.</p> <p>There is <i>coordination</i> between transportation and environment ministries.</p> <p>Many countries expressed a need to develop an approach to</p>	<ul style="list-style-type: none"> - Make connections to the European efforts to establish a leaching database [RMRC]. - Hold an AASHTO and state EPA workshop on the Dutch and European Union approach to evaluating product-leaching behavior [RMRC]. - Include state DOT Environmental Staff and state EPA staff on Innovations and New Product Reviews [AASHTO]. - Develop a model GIS layer to track recycled material use and aid future maintenance and management decisions. - Add an “Excellence in Recycled Materials Innovation” category in the annual FHWA Environmental Excellence Awards and the AASHTO Environmental Best Practices Award [FHWA, AASHTO]. - Encourage the U.S. EPA to work more with the state BUD programs to expand reciprocity [U.S. EPA]. - Encourage the U.S. EPA to continue to develop the federal procurement guidelines for recycled materials use in the highway environment [U.S. EPA]. - Perform long term monitoring [AASHTO, state EPAs]. - Hold a workshop on issues related to source

Subject	Findings	Recommendations [Lead Organization From Scanning Team to Act on Recommendation]
	<p>evaluate the <i>environmental behavior</i> of recycled materials and natural materials by looking at source terms, the fate and transport of their constituents, and their relation to human health and ecological risk.</p>	<p>term description, fate and transport, and risk [RMRC].</p>