

RESEARCH ACTIVITIES

REUSE OF WASTE AND RECYCLED MATERIALS

Acceptable disposal of wastes is a growing problem. Because of its high-volume consumption of bulk materials, the transportation industry is under increasing pressure to use waste and recycled materials. However, there are concerns about the suitability of such materials to use in transportation infrastructure. State departments of transportation need information to make appropriate use of these materials. Several projects being conducted under the National Cooperative Highway Research Program, the Federal Highway Administration, and state departments of transportation will develop information, procedures, and methodologies to aid in the use of waste and recycled materials. The following are examples of research projects dealing with this issue.

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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PROJECT 4-21

APPROPRIATE USE OF WASTE AND RECYCLED MATERIALS IN THE TRANSPORTATION INDUSTRY

The physical properties, short-term behavior during construction, long-term chemical stability, potential environmental problems, recyclability, and eventual disposal problems of waste and recycled materials are often unknown and must be well understood before these materials can be used on a routine basis. To help transportation agencies make prudent decisions, information is needed on each particular material being considered and its potential application.

The first objective of this research is to develop a methodology for assessing the suitability and practicability of specific recycled materials in transportation applications, determining appropriate uses, developing design and construction guidelines, and evaluating long-term performance in service. The second objective is to apply the methodology to a spectrum of recycled materials. The contract for the project has been awarded to Chesner Engineering, P.C. The principal investigator is Warren Chesner. The research team recently distributed the Alpha version of a data base of waste and recycled materials that could be evaluated for transportation purposes.

The final report for the project will be available in July 1998. A Technical Memorandum outlining the proposed methodology will be available in July 1996, and an Interim Report will be available in October 1997.

PROJECT 25-9

ENVIRONMENTAL IMPACT OF CONSTRUCTION AND REPAIR MATERIALS ON SURFACE AND GROUND WATERS

Construction and repair materials have only recently become the focus of concern for environmental quality, because a variety of recycled and waste materials are being considered for these uses, which increases the number of materials in contact with surface water and groundwater.

This research project is intended to identify potentially mobile constituents from highway construction and repair materials and their possible impacts on surface water and groundwater. Because waste and recycled materials have been identified as a class of materials that may pose some environmental risks, a portion of this research will evaluate their impacts.

The objective of this research is to develop a validated methodology for assessing the environmental impact of highway construction and repair materials on surface water and groundwater, and to apply the methodology to a spectrum of materials in representative environments. The research is being conducted by Oregon State University. Neil Eldin and Wayne Huber are principal investigators. The research team has developed a screening methodology to evaluate the potential for a toxicity problem in aquatic systems caused by construction and repair materials. The team will evaluate the leaching characteristics and kinetics of these materials, fully develop a predictive model,

and eventually validate the model and evaluation methodology in real world situations. Waste and recycled materials used or proposed for use as construction and repair materials are also being evaluated.

The final report for the project will be available in July 1997.

PROJECT 20-7, TASK 58 INFORMATION AND EVALUATION OF ASPHALT RUBBER RESEARCH

As a result of provisions in the Intermodal Surface Transportation and Efficiency Act of 1991, state highway agencies were required to construct pavements with crumb-rubber modifier (CRM), which has a long history of research to develop its use in the transportation industry. This project was initiated to inform the state DOTs of the results of previous research, and to update them about ongoing research. In addition to monitoring studies on engineering issues related to pavement performance, a specific focus was research into the environmental and health considerations for recycling asphalt pavements containing rubber.

The University of Nevada-Reno is the consultant and has distributed *CRM News Briefs* and *Updates*. A data base of all literature on the use of rubber tires in highways has been developed and advertised. Two workshops were held and a research agenda for crumb-rubber modifier was developed. The project is completed.

NCHRP PROJECT 20-5 SYNTHESIS OF INFORMATION RELATED TO HIGHWAY PROBLEMS

In 1994 NCHRP published two syntheses dealing with the use of waste and recycled materials. Synthesis 198, *Uses of Recycled Rubber Tires in Highways*, provides information on the uses of rubber tires in asphalt paving materials as well as other uses, such as in fills and embankments, for erosion control, and on railroad grade crossings. Specifically, information is included which identifies the highway agencies using or implementing applications for recycled rubber tires and defines the design parameters, technical and construction limitations, performance, costs, benefits, environmental limitations, specifications, and availability. Jon A. Epps, University of Nevada-Reno, was responsible for collection of the data and preparation of the report.

Synthesis 199, *Recycling and Use of Waste Materials and By-Products in Highway Construction*, provides information on technical, economic, and environmental aspects of recycling and on the specific applications of waste materials and by-products. It also provides information on the quantities, characteristics, possible uses, current and past research activities, and actual highway construction use of each waste material or by-product. Robert J. Collins, Collins & Associates, and Stanley K. Ciesielski, Villanova University, collected the data and prepared the report.

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RECYCLING FOR HIGHWAY CONSTRUCTION FEDERAL HIGHWAY ADMINISTRATION

The Federal Highway Administration is addressing the use of waste and recycled materials in highway construction through research and development and through engineering activities.

RESEARCH AND DEVELOPMENT ACTIVITIES

Two FHWA research projects are under way that will provide technical guidance in the use of waste and recycled materials. The first project is *Use of Waste Materials in Pavement Construction: Interim Guidelines and Research Plan*. The objectives of this project are, first, to develop guidelines based on the current state of practice and research that will assist state agencies or recyclers in safe and effective use of waste and by-product materials for pavement construction applications; and, second, to assess research needs and develop a research plan. The guidelines will contain the following information:

- A description of each material's origin and important physical and chemical properties from an engineering standpoint, with available representative values;
- Guidelines on appropriate test methods and standards for evaluating material properties, procedures for design and mix proportioning, construction equipment and methods, quality-control procedures, and tests and standards for predicting performance and evaluating health and environmental risks;
- A description of environmental issues involved in use of waste materials, and a methodology to assess a particular material-application combination from an environmental standpoint;
- A description of cost issues involved in the use of waste materials; and
- Guidelines for assessing the suitability of waste and by-product materials in pavement construction applications and for determining the most appropriate uses.

The assessment of research needs will identify knowledge gaps and issues that preclude the use of certain materials and suggest specific research and development tasks to resolve them. Strategies for selecting research and development priorities will be identified and used to produce a research plan that sets these priorities. Chesner Engineering, P.C., is under contract to assist the agency with the project.

The second research project is Evaluation of Use of Crumb-Rubber Modifier in Asphalt Pavements. FHWA published a report to the U.S. Congress in June 1993 summarizing the state of the practice for incorporating recycled materials, including crumb-rubber modifier, into highway pavements. The report concluded that further research is necessary to assess the performance characteristics and recycling potential of this type of asphalt concrete. FHWA entered into a 60-month contract with Oregon State University in September 1994 to resolve many of the outstanding technical issues identified in the report. This research program is designed to produce guidelines that can be used by state highway agencies to incorporate crumb-rubber modifier into asphalt pavements.

The overall objectives are to evaluate crumb-rubber modifier technology as it relates to design, construction, recycling, and performance of asphalt-concrete pavements. Products of the research will include guidelines for mix and structural design and construction of this type of

asphalt pavement. Guidance will also be developed for the production and quality control of crumb-rubber modifier mixes. The project will establish the long-term performance of these pavements and determine their recyclability.

ENGINEERING ACTIVITIES

In May 1995 the Environmental Protection Agency issued the Comprehensive Guideline for Procurement of Products Containing Recovered Materials (CPG). The CPG consolidated 5 existing item designations and added 19 new ones, including cement and concrete containing ground granulated blast-furnace slag (GGBFS).

Blast furnace slag is a by-product of iron production in a blast furnace, composed primarily of silicates and aluminosilicates of calcium. When cooled rapidly by immersion in water, and ground to a sufficient fineness, the resulting GGBFS exhibits cementitious properties that allow it to be substituted for a portion of the cement in a portland cement concrete mix. Although substitutions of up to 70 percent have been used, typical substitution rates range from 25 to 50 percent.

In implementing the requirements of the CPG, the Environmental Protection Agency recommends that procuring agencies allow the use of cement or concrete containing GGBFS as an alternative when appropriate. EPA also recommends that the procuring agencies review per-

USING GROUND RUBBER TO REMOVE PETROLEUM FROM WATER

Limited success in the containment and remediation of liquids containing petroleum products such as gasoline, oil, and solvents has led to increased interest in the development of new cost-effective technologies for remediation. Ground rubber from scrap tires may satisfy this need, as well as the need to develop a reuse market for used tires. Research has shown that many rubber polymers can sorb a variety of solvents, including aromatic hydrocarbons such as benzene, toluene, ethylbenzene, and xylene compounds (BTEX) in gasoline. One use of ground rubber as a sorption medium could be as an aggregate in slurry cut-off walls that are in contact with petroleum products. The swelling property of the rubber when exposed to BTEX may also help to decrease the liquid conductivity of a cut-off wall as organic compounds permeate the wall. Ground rubber could also be used as a sorption medium in pump-and-treat methodologies, or more importantly in in-situ reactive permeable barriers.

Initial research has shown that surface-treated, non-surface-treated, and differently sized tire-rubber particles have the ability to sorb O-xylene and benzene from water contaminated with these compounds. The sorption test results of ground rubber for benzene and O-xylene in aqueous solutions are promising. Further research is necessary to focus on the feasibility of ground rubber as an economically competitive sorption medium, and the ability of ground rubber to sorb multiple contaminants under natural groundwater conditions. The cost comparison should include the costs of regeneration or disposal, or both.

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formance standards to ensure that they do not arbitrarily restrict the use of GGBFS.

FHWA's implementation efforts will consist of ensuring that the use of this material is allowed where it is reasonably available and technically feasible. In those states where GGBFS is available at a reasonable price, specifications for projects authorized after May 1, 1996, must be revised to allow the use of the material. States in which GGBFS is not available

at a reasonable cost will not be required to modify their specifications, but must document the unavailability.

For further information about FHWA research and development activities to address recycling issues, contact Doug Brown, FHWA (telephone 703-285-2626, fax 703-285-3105). For information about FHWA engineering activities on this topic, contact James R. Powell, FHWA (telephone 202-366-8534).

EXPERT SYSTEM FOR MATERIALS REUSE KENTUCKY TRANSPORTATION CABINET

One of the objectives of the Kentucky Transportation Cabinet is to promote the use of recovered and recycled materials by the Kentucky Department of Highways, which already uses a significant number of waste materials in projects, including coal fly ash and bottom ash, boiler slag, blast-furnace slag, steel slag, and reclaimed pavement materials. In addition to the routine use of such materials, the Kentucky Transportation Center is currently monitoring a section for the Kentucky Department of Highways that contains a crumb-rubber modifier; the pavement section was placed in 1993. Plans are also under way to develop special construction notes for the proposed construction of a highway fill containing discarded-tire chips.

The cabinet selected the Kentucky Transportation Center to develop an expert system for the use of recovered and recycled materials in highway construction and maintenance. The system developed by the center uses a multidisciplinary data base that appraises all aspects of recyclable and recoverable materials use related to highway construction and maintenance: engineering, economic, regulatory, and policy issues. The system is flexible enough to allow expansion as new materials and regulations are developed.

A comprehensive literature search on the use of recycled and recovered materials in highway construction and maintenance was conducted at the University of Kentucky Transportation Center Library. Articles and reports were thoroughly reviewed for general and detailed information that was entered into the expert system. The literature search identified engineering, economic, and performance issues and focused on asphalt, portland

cement concrete, discarded tires, paint-removal wastes, fly ash, glass, alternative fuels, and other recycled and recovered materials. Regulatory and policy matters were investigated and included as data input to the expert system.

Initial input data for developing the decision-making model were obtained from the literature review. However, for some data input to the expert system, follow-up interviews with principal engineers who conducted research on specific topics may still be required to identify engineering and economic data associated with the use and overall field performance of the waste materials. Additional input data for the expert system must be developed through laboratory evaluations and performance of field trials. Recyclable and recoverable materials that have been used successfully in highway construction and maintenance applications outside of Kentucky should be evaluated under laboratory or field conditions, or both. Any application that would require putting waste materials in a confined condition should be worthy of serious consideration for field-trial evaluations, which are required to document valuable engineering experience and performance considerations.

The expert system will enable Kentucky Transportation Cabinet administrators to provide practical plans and comply with any legislative mandates pertaining to recycled and recovered materials use in highway activities. The system will provide an opportunity for transportation officials to anticipate the impact of various potential legislative actions related to the required use of certain materials. ■

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