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U.S. Department of Transportation

Federal Highway Administration

REPORT TO CONGRESS JUNE 1993

A STUDY OF THE USE OF RECYCLED PAVING MATERIAL

as specified in the Intermodal Surface Transportation Efficiency Act of 1991 Section 1038(b)

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TABLE 5. SUMMARY OF DISPOSAL PRACTICES

Material/Appurtenance Type	Average Percentage of Material	
	Disposed (1)	Reused/Recycled (2)
Asphalt Concrete: Surface Course	16	82
Base Course	16	82
Stabilized Base	27	65
Crushed Stone	16	67
Crushed Gravel	19	77
Granular Subbase	22	73
Stabilized Subbase	26	50
Shoulders, Asphalt	22	74
Concrete Culverts	74	22
Corrugated Steel Pipe Culverts	87	13
Wood Culvert	100	0
Multiplate Underpass or Culvert	66	26
Guard Rail	48	52
Guard Rail Posts (Steel & Wood)	54	42
Signs - Advisory and Regulatory	47	53
Sign Posts	56	44
Sign or Signal Pole and Structures	54	44
Bridges: Aluminum or Steel Railing	56	44
Steel Superstructure & Deck	63	37
Concrete Beams	83	12
Concrete Deck	89	11

(1) These materials may be buried on the project, landfilled, sold as scrap material, and/or disposed of as contractor property. These materials may be reused or recycled in non-highway applications.

(2) These materials are functionally reused or recycled in highway projects.

C. Performance

While pavements containing CRM have been constructed and have been in service for as many as 20 years in Arizona, California, and a few other States and based on an extensive review of available literature and project data, only limited information on engineering and economic performance is available. This is due to limited documentation, experimental evaluation, and a resulting incomplete data base upon which to conduct long-term performance evaluations. While other States have conducted limited experimental research with CRM technologies, the performance of asphalt pavements containing recycled rubber has received only limited evaluations under varied climatic and use conditions.

In order to develop a reliable cost and economic evaluation of pavements containing CRM, comparable information must be developed on the construction of CRM asphalt paving projects of typical size rather than experimental applications. The performance to date on the CRM projects has been mixed, some experiencing early failure, others performing comparably to conventional asphalt pavements, and some CRM pavements have performed better than conventional mixes. Due to limited documentation, the exact cause of the premature distress in CRM pavements has not been established. However, when properly designed and constructed, there is no reliable evidence to show that pavements containing recycled rubber will not perform adequately as a paving material.

We will continue national research on CRM technologies to develop reliable engineering and economic criteria for the CRM pavements. Additionally, many States are conducting coordinated research to evaluate the effects of local conditions and materials. The results of these studies will be included in long-term performance evaluations.

OTHER RECYCLED MATERIALS

In the last 30 years, the generation of solid waste in the United States has increased twofold. This increase coupled with the concern of society regarding environmentally safe and efficient disposal of these materials dictates the need to find alternative uses. Economic and engineering alternatives for reuse of waste products in highway applications should continue to be identified, evaluated, and developed.

The highway community pioneered the use of waste materials beginning with asphalt, a waste product of the crude oil refining industry. A long history of incorporating by-products and waste materials exists today. Recycling of asphalt pavements has received extensive use in the United States since the mid-1970's. Current recycling practice today is determined by the availability of suitable materials, economic costs, and performance.

Studies were conducted on the use and application of waste products within the highway environment. A wide array of ideas, concepts, and applications for waste products exist. Documentation on environmental and human health risks, engineering criteria, costs, economic savings, and performance varies from limited to extensive, depending on the material and application. Only limited information on the environmental benefits of using these materials in highway applications exists today.

A. Reclaimed Asphalt Pavement

Most State highway specifications permit the contractor to incorporate a percentage of RAP into asphalt pavements to the extent the recycled HMA meets existing specifications for new materials. In the United States, over 80 percent of the asphalt pavement removed is reused in highway applications.

Current asphalt pavement recycling practices utilize 10 to 22 percent RAP in recycled HMA production using conventional hot mix plant technology. State-of-the-practice conventional technology has demonstrated the capability to recycle asphalt pavements at a maximum of 50 to 70 percent RAP for properly engineered hot mix materials without adverse engineering or environmental problems. The exact percentage of RAP that can be successfully incorporated into a given recycled mix is dependent on the in-service pavement materials properties and field conditions. Recycling, as a pavement rehabilitation technique, generally will not enhance the basic materials properties of the pre-existing pavement. To meet materials engineering criteria for many recycled mixes, RAP is often included at a lower percentage than the maximum percentage at which a conventional HMA plant can operate efficiently and continue to meet environmental standards. Hot in-place recycling has been developing since the mid-1970's. Hot in-place recycling has been performed on asphalt pavements using in excess of 80

percent RAP, but the results have been aging of the asphalt cement and excessive emissions. New technology is under development to address this problem. Cold recycling has been used successfully on medium- to low-volume roads to recycle 100 percent RAP. Microwave technology is now available that has demonstrated the capability of hot recycling of asphalt pavement within current emissions standards at RAP percentages of 80 percent and greater. This technology has had only limited utilization to date and is proprietary.

HMA pavements utilizing 80 percent RAP produced with conventional hot mix technology result in early aging and oxidation of the asphalt cement and unacceptable air quality emissions. Cold-mix recycling has been performed successfully for in-place and central plant production. Comprehensive information on the performance of cold in-place recycling is not available and life-cycle costs have not been determined. Mixture design and analysis procedures are limited and require further development. Paving projects constructed utilizing microwave technology are performing satisfactorily to date.

State highway agencies report a cost savings when using RAP. Recycling of asphalt pavements using various percentages of RAP is a proven technology and with proper engineering and mixture design, recycled HMA can be considered an appropriate substitute material as provided for under subsection 1038(d)(2) of ISTEA.

Additional information on the use of RAP at the 80 percent or greater level for the various recycled asphalt mix production technologies is needed for long-term performance, engineering design, economics, and environmental and human health impacts. FHWA will continue to develop and advance this technology as a viable alternative reuse resource.

B. Recycled Glass

Glass is a significant component in the solid waste stream. It is highly suitable for solid waste recycling. Its use as a substitute paving material has been demonstrated. The economics of using waste glass are highly dependent upon availability. In general, large quantities of waste glass are found primarily in major metropolitan areas. The analysis indicates limited potential for risks to human health and the environment. Significant literature and experimental project data are available to support the use of recycled glass in properly engineered asphalt pavement mixtures up to 15 percent. Thus, the addition of recycled glass into HMA mixtures can be considered as an appropriate substitute material as provided for under subsection 1038(d)(2) of ISTEA.

C. Recycled Plastic

Like glass, plastic is also a significant part of the solid waste stream. However, only limited reuse of waste plastics exists today. Plastics in the waste stream vary significantly in chemical composition. To date, we have extremely limited experience with the use of recycled plastics in highway applications. The use of plastics as a polymer modifier in asphalt pavements exists today. While there are several technologies available to blend virgin plastics with asphalt cements to produce a polymer modified binder, the chemical variability in recycled plastics has been a significant deterrent to the use of waste plastics in pavements. Two known HMA paving products that utilize waste plastics exist. Only limited performance, economic, and environmental data are currently available. Therefore, the use of recycled plastics in asphalt pavements is not considered an appropriate substitute material under subsection 1038(d)(2) of ISTEA at this time. We will continue to work with the States and industry to evaluate the emerging asphalt paving products and applications.

Based on the review, we have identified other potential highway applications for reuse of recycled plastics. We will continue to develop and promote the use of these technologies as appropriate.

D. Other Recycled Materials

Our research revealed many potential applications for reuse of waste and by-product materials within the highway setting. Only limited information is available for many of these waste products. A waste materials symposium, "Recovery and Effective Reuse of Discarded Materials and By-Products for the Construction of Highway Facilities," is scheduled for October 1993. The objective of this symposium is to identify and disseminate current state-of-the-art information on new and innovative methods for effective recycling and reuse of waste by-products within the highway system.