

FROM
REFUSE
TO
REUSE



ADVOCATES & AGGREGATES

WASHINGTON STATE
INCLUDES
NEW PARTNERS IN RECYCLING

KEITH W. ANDERSON

In 1991 the Washington State legislature required the state department of transportation to study the use of recycled materials for road construction. The major objectives of the study were to examine which types of recycled materials, such as glass and discarded tires, are appropriate and feasible as alternative paving materials; and which types of recycled materials, such as mixed plastics and compost, are useful in transportation applications other than pavements. The study was to be conducted in concert with the Clean Washington Center, a department of the Washington State Department of Trade and Economic Development that promotes the development of markets for certain recycled materials.

The research required by the state legislature focused the attention of the Washington State Department of Transportation on the use of waste and recycled materials and brought the department into contact with the recycling community, including many strong advocates for such reuse. The legislative mandate focused the advocates' attention on WSDOT as a potential user of large quantities of these products. Many recycling advocates urged the department to approve and use waste or recycled materials immediately, wherever any evidence could be found that a material had been used in a highway application. WSDOT approached the issue cautiously, emphasizing that approval should be based on testing and performance evaluations, and that a value-engineering approach was needed to assure that the traveling

public would receive the utmost value for its tax dollars. This stance is in keeping with the department's stated mission to "design, build, and maintain a quality highway system in the most efficient and cost-effective manner."

During many exchanges, the recycling community and transportation department staff debated the feasibility and timeliness of reusing specific waste materials. Through a series of meetings involving members of the recycling community, the Clean Washington Center, and representatives of WSDOT, the recycling community gradually came to recognize the problems that the use of recycled materials in transportation could raise, and the department came to understand the urgency of testing and evaluating these waste and recycled materials as promptly as possible. The Clean Washington Center, which represented the middle ground in this debate, frequently defended the stance of the Washington State DOT, and was especially supportive of the department's caution regarding materials such as crumb rubber and glass in asphalt pavements. After reviewing the experience of Washington and other states with these materials, the Center representatives agreed that the cost of adding crumb rubber might be prohibitive and that using glass in asphalt did not make engineering sense for the high traffic conditions on the majority of the state roadways.

The recycling study, although a milestone event with respect to the attention focused on the department by the recycling community, was not



WASHINGTON STATE DOT

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the agency's first encounter with recycling. The department has been testing, evaluating, and using recycled materials in roadway construction and other highway-related applications for more than 25 years. Many of the product evaluations were conducted under the federally sponsored Experimental Features Program, which allows the trial use of new products or procedures on construction projects. For the past 10 years WSDOT has also used a New Products Evaluation Committee to oversee the evaluation of new products submitted to the committee by private vendors. Both of these programs have been used to evaluate waste and recycled materials. Products that have been experimented with or for which applications were developed in the past 25 years include scrap tires, glass, asphalt and concrete pavement, plastics, compost, and aluminum sign stock.

RECYCLED ASPHALT PAVEMENT

WSDOT has aggressively developed specifications and processes to increase its use of recycled asphalt-concrete pavement (ACP), which the department has been actively recycling since 1977. The first use of recycled ACP was on a 6.4-kilometer (4-mile) section of Interstate 90, which runs east and west through the center of the state.

The use of this material began slowly. It involved a series of experimental projects that used a fairly high percentage of asphalt-concrete pavement millings produced in the individual projects. These experimental projects met with significant resistance from the paving industry because the recycling process did not fit their existing production equipment or processes. Approximately five years after the first recycling project, when evaluations of the completed experimental efforts revealed no serious drawbacks to recycling, WSDOT rewrote its existing specifications to include the use of recycled ACP. The specifications made three changes to past practice:

- A maximum of 10 percent recycled ACP from any source can be included in new asphalt-concrete pavement without a specific recycle mix design. This has since been increased to a maximum of 20 percent.
- All asphalt-concrete pavement removed from a project becomes the property of the contractor for reuse or disposal.
- The contractor may use up to a maximum of 80 percent recycled ACP in any new asphalt-concrete pavement, provided the resulting pavement meets standard recycled pavement design

criteria. These criteria call for the rejuvenation of the old liquid asphalt to standards comparable to new liquid-asphalt standards, with grading and density standards to be the same as those for new asphalt-concrete pavement.

These specification changes were designed primarily to make recycled material available to the contractors and to allow the contractors to compete at recycle percentages that best fit their own hot-mix plant operations. Those who could use more of the cheaper recycled ACP obviously would have a competitive edge.

At about the same time as the specifications were changed, several of the state's paving contractors purchased new hot-mix plants specifically designed to incorporate recycled asphalt concrete pavement in the hot-mixing process. After a few contractors began competing using this material, which costs less than new materials, the process was generally adopted by the paving industry. Between 1977 and 1981, WSDOT recycled slightly more than 20 865 metric tons (23,000 tons) of asphalt concrete pavement; by 1984 the department had recycled more than 272 156 metric tons (300,000 tons).

Washington State uses between 90 719 and 181 437 metric tons (100,000 and 200,000 tons) of recycled asphalt-concrete pavement per year in its highway preservation program. The specifications are also used by many cities and counties, which collectively recycle approximately the same quantity of the material in their construction programs. Benefits of such recycling include a decreased dependence on oil for producing asphalt, a reduction in the amount of asphalt pavement dumped in landfills, and diminished need to quarry new aggregate. This is all accomplished without adversely affecting the pavement preservation program, since the performance of recycled asphalt concrete, as specified, is about the same as new asphalt concrete, and the cost is slightly less.

The cold-mix, in-place recycling process has also been evaluated through the state's Experimental Features Program. Three projects were evaluated after six years; it was generally concluded that they were performing satisfactorily. Few cold-mix recycling projects have been built since this initial evaluation, for several reasons: risks are associated with this process because curing is necessary and relies on evaporative conditions (high temperature and low humidity); special milling, mixing, and placing equipment are necessary to properly construct a project; and alternatives exist that are easier to use and do not require curing time or special equipment.



In 1977 Washington State began investigation of crumb rubber to develop a rubberized asphalt stress-absorbing membrane interlayer at sites such as Jackson Highway, State Route 12.

CRUMB RUBBER

At approximately the same time that WSDOT began to experiment with recycling asphalt-concrete pavements in 1977, it also began to experiment with crumb rubber from discarded tires. The initial uses of rubber occurred in 1977 when the Arizona Process was used to produce a rubberized chip-seal interlayer to prevent reflection cracking through an overlay. A year later the same process was used to produce a chip-seal surface treatment. In 1982 the department paved its first small experimental section of dense-graded pavement using the PlusRide product and tried its first open-graded friction course overlay using the International Surfacing wet process.

Between 1977 and 1986 WSDOT applied 142 lane-kilometers (88 lane-miles) of rubberized chip-seal surface treatments, used 171 lane-kilometers (106 lane-miles) of rubberized chip-seal interlayers, built 47 lane-kilometers (29 lane-miles) of open-graded rubberized friction course, and used the PlusRide product on 8.5 lane-kilometers (5.3 lane-miles). All of these products or processes were evaluated for long-term performance and cost-effectiveness through the WSDOT Experimental Features Program. These investigations revealed that, of all the processes and products, the open-graded friction course overlay using the wet process seemed to be the

only one that gave consistently satisfactory performance, although at a substantial increase in cost over conventional pavement mixes.

In 1991, in response to the passage of the Intermodal Surface Transportation Efficiency Act, which required the use of crumb rubber in asphalt pavements, WSDOT began to use a new crumb-rubber product developed by a local asphalt supplier. This product uses fine-grind (less than 80-mesh) rubber blended into the liquid asphalt at the supplier's facility. The supplier found that the resulting blend, at about 8 to 9 percent rubber, had many of the same enhanced properties as a polymer-modified asphalt. It also did not have many of the disadvantages of other wet-process products, such as settling during storage, requirements for special pumping equipment at the plant, and the need to use the product within a certain time of blending.

In 1992 WSDOT paved its first project with this blended product on a section of Interstate 5 south of the state capital of Olympia. Additional projects were successfully paved in 1993 and 1994 to bring the total use to 18 597 metric tons (20,500 tons). The sections have performed satisfactorily in the short period of time since placement. The price of the mix made with the blended product has ranged from 4 to 45 percent higher than conventional mix. The higher cost

was incurred on the first project, in which the quantity used was low. The product has successfully demonstrated its effectiveness in application, can be ordered by a contractor directly from a supplier, and requires no special handling, mixing, or storage. Time will tell if the performance justifies the added cost.

SCRAP TIRES

Discarded tires are also being recycled into embankments in the state of Washington. Two such projects, using tire chips, have been built in areas where landslide potential dictated the use of a light-weight fill material. A total of 4587 cubic meters (6,000 cubic yards) of tire chips were used in these projects. The tires were provided at no cost to the contractor through a program administered by the Washington State Department of Ecology, which pays tire recyclers to clean up discarded tires using revenues from a fee of \$1.00 assessed for every new tire sold by retailers in the state. The recyclers were required to market the tires or dispose of them in some way other than landfilling. The tire assessment fee expired in 1993 and has not been reinstated by the state legislature.

WOOD FIBER

The Washington State DOT has been using waste wood fiber (sawdust, bark, hogfuel) for light-weight fill in landslide-prone areas since 1972. Initial use of the material was based on its all-weather properties; its lighter weight, which lessens the driving forces on unstable subgrades; and its ready availability in locations where it was needed. Long-term performance evaluations have shown that the fills have an expected life of more than 20 years, although some installations built with aged wood fiber are showing degradation. Fills built with fresh wood fiber are not showing degradation. The normal precautions of not allowing large volumes of water into the fill, using a minimum 0.6 meters (2 feet) of surfacing materials over the fill, and covering side slopes with 0.6 meters (2 feet) of soil cover are similar to other states' recommendations for wood-fiber fills.

GLASS

One of the most interesting products for recycling has been waste glass (cullet). WSDOT has been allowed the use of glass as an aggregate in asphalt-concrete pavement since the 1960s. Reports from other states indicate problems related to how much more easily it can be crushed than natural aggregates; its smoothness, which prevents asphalt from sticking readily to its surface; and its

frequent contamination with other wastes such as aluminum cans, soil, and ceramics. To address these concerns, the Clean Washington Center conducted a study to investigate the use of glass as an aggregate. The \$250,000 effort was funded by several state DOTs, environmental quality agencies, waste-management agencies, and private waste-management companies.

The objective of the study was to provide the necessary information on cullet properties and processing so that engineers could specify the use of cullet as a construction aggregate with confidence, and so that recycled glass aggregate suppliers could invest in market development with minimal risk. The study defined the suitability of cullet as a construction aggregate in terms of its engineering performance, environmental impact, cost compared with natural aggregate, and safety in handling.

The report produced by the Clean Washington Center concluded that cullet would perform well as a construction aggregate, especially when mixed with natural aggregate. Debris contamination does not seem to be a problem as long as it is below 5 percent by visual classification. In many cases, depending on local conditions, glass can be competitive in price or less expensive than conventional aggregate.

As a result of the Clean Washington Center study, WSDOT changed its specifications to allow up to 15 percent glass in aggregates for base courses, backfill for foundations, pipe bedding, and other applications that are not subject to heavy or repetitive loads. Despite the extensive effort to promote glass as a construction aggregate, the department has yet to use any glass on a construction project. This may not be the case for other local agencies within the state and the other sponsors of the glass evaluation project.

Long-term performance evaluations show that wood-fiber fills can last more than 20 years.





UNTIRING EFFORT

Washington State's Response to Recent Recycling Snag

In January 1996 Washington State DOT personnel noticed unusual cracks forming on a shredded-tire embankment that had been completed two months earlier. Within days steam was observed escaping from the cracks, and WSDOT personnel measured temperatures inside the gravel shoulder as high as 74 degrees Celsius (165 degrees Fahrenheit). WSDOT implemented a monitoring program to measure settlement and surface temperature and to sample groundwater, soil, and air quality at the site. Conditions continued to worsen.

When an oily substance was found leaking from the drainage blanket in mid-March, a spill-response team was summoned and plans to excavate the shredded tires were implemented. Temperatures within the embankment may be as high as 816 degrees Celsius (1,500 degrees Fahrenheit); flames, smoke, and steam surface continually. These conditions make the removal and cooling process time-consuming. Fortunately excavation has proceeded smoothly and the highest-temperature tire material has been removed.

Suspected causes of shredded-tire fires are not well understood. Exothermic reactions that may produce heat leading to such consequences include oxidation of steel belts and microbial action on tire rubber.

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FLY ASH

Laboratory research and field studies have led WSDOT to allow fly ash in all portland cement concrete pavements and in most structural concrete for many years. When used in the construction of pavements, fly ash enhances the workability of fresh mix. Several factors have led to the rapid adoption of fly ash in Washington State: the availability of high-grade fly ash in the Northwest, the incentive paid by the Federal Highway Administration for the use of fly ash, quick development of specifications by the American Society for Testing and Materials and the American Association of State Highway and Transportation Officials, and favorable response to the product by contractors who used it.

COMPOST

Until just a few years ago, WSDOT's standard product for increasing the organic composition of soils used for landscaping was a mixture of sawdust and bark. With the advent of yard-waste recycling programs in many of the urban areas of the state, compost became a viable alternative to the sawdust-and-bark mixture. The department's landscape architects were reluctant to begin using compost until they gained the assurance of suppliers that certain quality standards could be met by this new product. Once these questions were answered, compost was used whenever a soil amendment product was specified.

Compost is a highly effective product from a horticultural standpoint. Original supplies of compost used by WSDOT were derived exclusively from yard waste. As the department becomes more familiar with the quality of the product and how it works in promoting plant growth, its guidelines for use of the product are changing. Currently up to 35 percent sewage sludge is permitted. This allowance is raising concerns from DOE when compost is used near wetlands. DOE is concerned about minerals or liquid wastes from sewage sludge polluting the wetlands or changing the balance of nutrients in the water. The only problem encountered so far is uneven supply. Some areas of the state have not been as aggressive in pursuing recycling and therefore do not generate sufficient yard waste supplies to support a composting operation.

RECLAIMED PORTLAND CEMENT CONCRETE

One of the newest recycling products to be used in highway construction is reclaimed portland cement concrete pavement (PCCP). Reclaimed PCCP is processed in the Seattle metropolitan area



for use in a variety of applications. WSDOT allows the use of recycled concrete rubble as or blended with the following: ballast; shoulder ballast; crushed surfacing base and top course; maintenance rock; gravel backfill for foundation, walls, and pipe bedding; gravel borrow; bedding material for rigid pipe and flexible pipe; and foundations material. The recycled concrete must meet the same specifications for wear and degradation, gradation, sand equivalent, and fracture as natural aggregates for the type of aggregate being used. The specifications allow for up to a maximum of 10 percent by weight of recycled asphalt pavement in the blended product. The contractor must also certify that the recycled material is neither hazardous nor toxic.

Reclaimed PCCP is being used mainly in the Seattle metropolitan area for a number of reasons. One factor is that the supplies of natural aggregates are being depleted within the metropolitan area and haul is becoming a cost factor in the use of natural aggregate. Another factor is that the reclaimed pavement makes a very good base course because a secondary cementation takes place when the material is compacted. The portland cement reacts with the water added to help the compaction process; the result is a mildly cemented base material that is hard and durable. It should be noted that the aggregates found in the Seattle metropolitan region are among the hardest and most durable in the world. Recycling them back into roadways not only makes economic sense, but is an excellent way to conserve a natural resource that few other locations possess.

PLASTICS

Reuse of plastics by WSDOT has been limited. Plastic lumber was one of the first products promoted to the state. However, because plastic lumber suppliers have been unable to provide WSDOT with the necessary structural application tests and specifications, plastic lumber is allowed only in nonstructural applications. Only a small quantity of the material has been used in the past three years.

ALUMINUM SIGN STOCK

Aluminum sign stock is among the more unusual recycled materials Washington State has incorporated into transportation applications. A state corrections facility purchased the equipment necessary to remove the reflective sheeting from damaged sign stock, which is sent to the prison to be stripped, cleaned, and prepared for reuse. Cities and counties in the state also use the facility, and neighboring states have expressed an interest



in participating. The savings derived from this recycling program are significant. Signs can be recycled for one-third to one-fifth the cost of purchasing new sign stock, depending on the thickness of the aluminum. In one year more than \$200,000 was saved by using this process.

NEW HORIZONS

The recycling program of the Washington State Department of Transportation reflects longstanding efforts to save money, ensure performance, and use waste and recycled materials sensibly. The Clean Washington Center is an ally in these efforts, explaining the department's concerns about waste reuse to the recycling community and mediating between the two groups when viewpoints conflict or different solutions are supported. The Clean Washington Center also continues to prod transportation personnel to clearly identify their concerns while continuing to experiment with new uses for waste and recycled materials to the extent appropriate.

The New Products Evaluation Committee is examining private sector innovations in the use of waste and recycled materials. The Experimental Features Program is being used to evaluate new products and processes. The first hot in-place recycled pavement was contracted in summer 1995; the product's performance will be evaluated through the EFP process.

The department's use of compost continues to increase. The use of reclaimed portland cement concrete is also expected to stay on an upward trend as landfilling fees continue to rise. Plastic lumber suppliers are being pressed for data on structural design criteria, and scrap tires and wood waste are considered first when the need arises for a lightweight fill material.

Several reports on glass recycling are available from the Clean Washington Center (telephone 206-587-5520).

Washington State DOT constructed its first rubberized asphalt pavement in the 1980s.