WASTING NO TIME

Florida's History of Successful Recycling for Transportation

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For decades road construction has incorporated readily available materials into smooth, safe, and appealing paths to transport people and goods. During Florida's settlement in the 19th and 20th centuries, trees removed for road construction or land development were often used to build bridges or "corduroyed" and plank roads suited to swampy conditions. As time passed, local clays and limerock were used in pavements to stabilize the ground and provide more reliable surfaces for vehicles. Placement of hard surfaces on these stabilized roads provided more dependable routes. The idea of creating a useful product from the black residue from petroleum distillation led to the development of early blacktop roads, a new alternative for providing hard-surface roadways.

As Florida has grown, so have its transportation needs. The enormous influx of new residents has required new and safer routes to allow individuals to reach remote, undeveloped regions of the state. The increase in population and the additional use of transportation routes by tourists have also accelerated the need for rehabilitation and replacement of existing facilities, a need that competes with new construction for attention and resources.

The state's growth has resulted in an increase in the waste generated by residents, visitors to the state, and industry. In 1988 the Florida legislature acknowledged the magnitude of the problem and, through Senate Bill 1192 (codified as Section 336.044 of the Florida Statutes), required the Florida Department of Transportation to research uses for waste materials in construction and maintenance projects and apply its findings. Materials specified for study included fly ash (for use in concrete), plastics, metals (especially reinforcing steel bars), glass, motor oil, and ground rubber (for use in asphalt). The statute also stipulated that FDOT fund relevant research through the state university system.

FDOT has instituted numerous programs over the years to use available and appropriate recycled materials. The oldest such program, in place since the late 1970s, specifies the use of reclaimed asphalt pavement. Basic research on the applicability of recycled materials is initiated at the department's State Materials Office in Gainesville, where many recycled products are also evaluated.

In developing its programs for the use of recycled materials and waste products, FDOT has considered one of the definitions of waste: "to fail to take advantage of or use for profit; lose; waste an opportunity." The department's policy is to drastically reduce the amount of discarded material through innovation and careful research. By thoroughly studying and reevaluating each transportation construction element, the State Materials Office seeks to eliminate material that is not suitable for operations.

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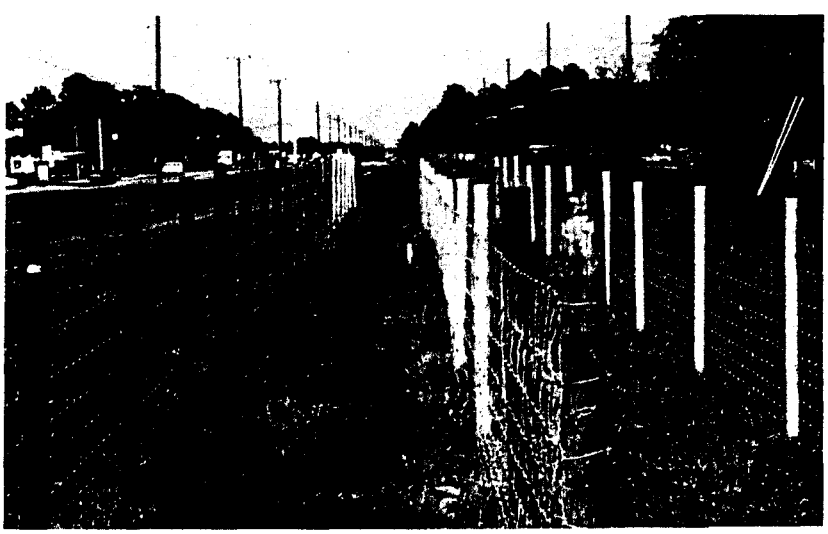
Recycled plastic fence posts along right of way.



FLORIDA DOT

RECYCLED PLASTIC COMPONENTS

The Florida recycling statute specifically required an investigation into the possible use of plastic waste in fence and guardrail posts. The University of Florida and the State Materials Office collaborated on a recycled plastic study in November 1988. The rigid technical requirements necessary for guardrail posts as components of a safety system raised doubts about the feasibility of building them from plastic. The researchers decided to focus the study on line fence posts.

A review of the literature revealed virtually no publications on the structural properties of recycled plastics. Testing equipment had to be designed and built to obtain data to support the writing of a specification. Because FDOT uses a performance-oriented approach to approving

products for use, a concurrent long-term field evaluation supplemented laboratory testing.

All types of recycled plastic posts, many resembling construction-type lumber, were obtained from plastics producers for testing. Cross sections ranged from 15.2-centimeter (6-inch) diameters and squares to members measuring 2.5 by 5 centimeters (1 by 2 inches). All items were mounted outdoors in a test facility at the State Materials Office to provide an initial assessment of exposure resistance and durability. After five years the posts were removed and evaluated. As expected, the smaller the cross section of the post, the greater its tendency to warp.

A total of five manufacturers of recycled plastic supplied the posts for the laboratory evaluation phase of the study. The performance requirements for line fence posts were evaluated, and the essential property measurements were identified. Equipment was redesigned or modified to measure these properties and, whenever possible, put under computer control.

The first fence posts tested were generally of poor quality. Several manufacturers supplied fence posts that were irregular in shape, with multiple interior voids (exceeding 25 percent by volume), rough surfaces, undissolved pieces of plastic, or warping. The majority of the manufacturers employed postconsumer plastics of all types (commingled) as opposed to using only industrial plastic waste. Industrial waste has a mostly homogeneous composition—usually high-density polyethylene from milk and juice bottles—and produces posts with a more uniform composition. The properties of such posts are more consistent along their entire lengths.

Manufacturing with commingled postconsumer plastics requires frequent adjustments to process conditions. For example, if the melt temperature is raised sufficiently to dissolve the higher-melting plastics in the mix, the low-melting plastics may decompose and ruin the batch composition. Most manufacturers chose a process melt temperature that would not decompose the lower-melting plastics but would fail to liquefy some of the high-melting plastics. The posts produced contained small pieces of undissolved plastic throughout their lengths and breadths. Each section of undissolved plastic formed grain boundaries within the remaining plastic matrix, resulting in areas of weakness and reduced physical property values.

In some instances, in order to meet production levels, posts were extruded and cooled too rapidly in the water bath. Rapid cooling caused immediate surface solidification and trapped steam inside, carving out large voids within the posts. As the manufacturers gained knowledge and experience working with recycled plastics, however, the appearance and functional properties of the posts improved.

After two years of laboratory testing and outdoor evaluation of the recycled posts, FDOT agreed to a statewide field test. The department purchased 1,000 posts from each of the five producers and arranged for the Maintenance Department to use them as replacements, distributing equal numbers from each producer to each location. The test provided data covering all soils and climates within the state. Ongoing evaluations have been conducted on site since the year after installation.

A completed specification is under review by the Federal Highway Administration. Among the tests in the specification are insect resistance for both fire ants and formosan termites, water absorption, stress/strain and flexure to failure, staple pull-out, stress relief by accelerated thermal aging, and resistance to burning.

Recycled plastic fence posts are expected to be less expensive than treated wood posts based on life-cycle cost analysis, which considered the costs associated with maintenance and replacement of the traditional treated wood posts. Recycled plastic post performance has been encouraging.

New materials and products made of recycled plastic continue to be submitted to the FDOT State Materials Office for evaluation. The state purchasing statutes require 10 percent additional payment to producers for components containing recycled material; 15 percent for components from Florida. This requirement provides an incentive to industry to find innovative uses for waste materials.

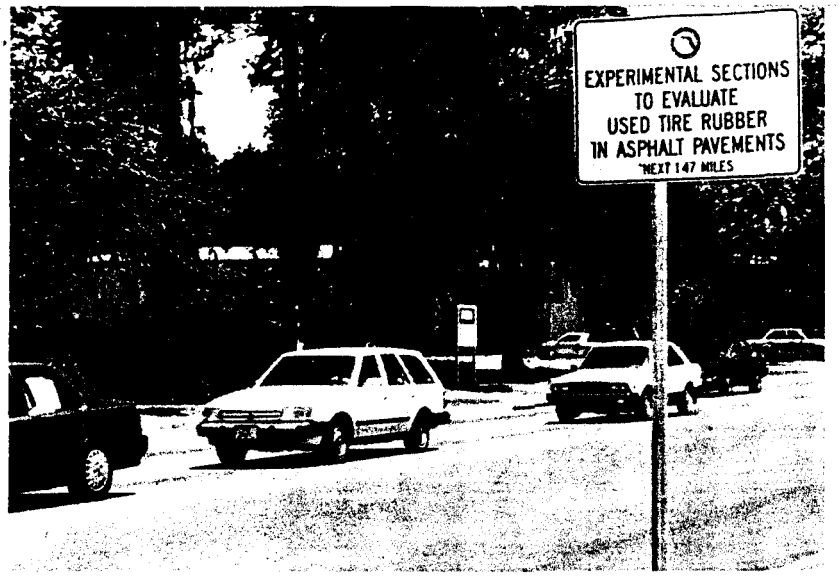
The department is most interested in the effects of exposure to marine environments, high humidity, and high daily temperatures on the plastic

PLASTIC'S MANY FACETS

The Florida Department of Transportation has gone beyond the state legis ment to include other products in its plastics testing program. Recycled pl have been approved for state use or are awaiting approval include the follo

Pull posts
Guardrail blockouts
Flexible delineator posts
Rebar support chairs and bolsters
Sign substrates
Fender systems for bridges
Blockout covers
A-frame barricades
Sound barriers
Drain pipe
Car stops
Parking mats from tires (in compliance with Americans with Disabilities Act)
Rubber mats and sign-post mats from tires (in compliance with Americans with Disabilities Act)
Initial studie additives
Spinning cu reflective work zo alternati lights
Plastic dr
Sign posts

Note: Specifications for products in bold type are written or awaiting FH



FLORIDA DOT

Test section of pavement includes ground tire rubber.

products tested. Materials and systems intended for use in areas with conditions dissimilar to Florida's require additional testing for each specific application. Data and information generated on recycled plastics used by FDOT have been supplied to many other state DOTs, national transportation agencies in several other countries, private enterprises, and environmental organizations.

Use of Recycled Motor Oil

Floridians generate 261 million liters (69 million gallons) of used motor oil each year. When FDOT was given the responsibility of investigating methods for diverting this material from the waste stream in 1988, the department had already been studying recycled motor oil as a heating fuel for asphalt and cement production. Because the legislature requested a report before the study was completed, a questionnaire was sent to industry representatives to determine interest in and the feasibility of large-scale use. Slightly more than one-half (51 percent) of those who received the poll responded. The responses indicated that the asphalt and cement industries would use up to 38 million liters (10 million gallons) of recycled motor oil each year if it were available. The fuel cost savings that would result from this use were estimated at 25 to 33 percent.

The report submitted in December 1988 by FDOT and the University of Florida recommended the formation of an advisory committee to oversee and establish appropriate regulations for the use of recycled motor oil. The Used Oil Management Program was strengthened by the 1988 Solid Waste Management Act; the Florida Department of Environmental Protection has assumed control of monitoring efforts to recycle used motor oil. Regulations and programs put into place since 1988 require annual tracking and reporting of used-oil recycling. The most recent report indicates that almost 30 percent of Florida's used oil was recycled as fuel in 1994.

Reclaimed Asphalt Pavement

Florida's program for reclaimed asphalt pavement, already well established by 1988, demonstrated the feasibility of reusing materials and established a procedure for evaluating, testing, and carrying out a recycling program. From 1979 to 1994, 22 million metric tons of recycled mix were placed on FDOT projects, saving more than $188 million in materials costs alone, not including cost savings for local road projects. However, approximately one-third of the total metric tonnage of mix that is contracted for annually is either fine- or open-graded surface course mix, for which reclaimed asphalt pavement is not a suitable component.

Although reusing all of the reclaimed asphalt pavement within the same project is virtually impossible, a large surplus has not developed. Contractors, who retain ownership of the milled material, are using it at sites where there is no milling. Reclaimed asphalt pavement also is incorporated into city, county, and development projects. Early projects averaged a mixture with 50 percent reclaimed asphalt pavement, but since 1990 the mixes have typically contained approximately 35 percent recycled material.

Florida's use of reclaimed asphalt pavement has been successful for four reasons: the department's commitment to the product and to educating all interested parties about its value and properties; specifications that assure quality and affordability; characterization of reclaimed asphalt pavement and mix design based on study and analysis; and contractor ownership of the recycled material.

FDOT staff and the product developers (equipment manufacturers, materials suppliers, and asphalt contractors) spent the time necessary to win support for the recycling program. This partnering effort, which created a sense of shared but acceptable risk, was the first and most crucial step toward success.

Asphalt mixtures containing reclaimed asphalt pavement must meet the same quality standards and perform as well over time as mixtures from virgin materials. The Florida specification allows reclaimed asphalt pavement as a component, but does not require its use. Nonetheless, the material is present in almost every paving project in Florida where its use is appropriate. Disposal of asphalt pavement material in landfills is virtually nonexistent.

Identification of the material to be reused is an essential element of the reclaimed asphalt pavement program. To determine the characteristics of an existing pavement, FDOT cores and classifies its components. Information on gradation, asphalt

content, recovered penetration, and viscosity is provided in the bid documents for each project. Standardized information puts all contractors on an even footing to propose mix designs. It is important that the mix design be representative of what the contractor is going to produce and use. Gradation of the reclaimed material is important, especially the amount of dust in the mix. Also important is the viscosity of the old asphalt since this will dictate the viscosity of the asphalt rejuvenator.

When a contractor owns and stockpiles the material milled from a project, an incentive to reuse it is created. A critical component of FDOT's specification is that it must bid its asphalt mix by the ton or square yard and its milling by the square yard. Low-bid competition ensures that prices include an allowance for the ownership of recycled material.

Ground Rubber in Asphalt

In January 1994 FDOT began using recycled ground tire rubber in all surface course mixes. The process to approve this material in asphalt mixes began with the need to improve the performance of the state's surface course mixes, the durability of its open-graded mix, and the distortion resistance of its dense-graded mix. The legislation enacted in 1988 was an additional impetus.

Laboratory work identified a promising variation of the traditional McDonald wet process for incorporating recycled ground tire rubber into asphalt cement. Lower rubber content and smaller rubber particles than are standard for each mix application were used, then the recycled rubber and asphalt cement was blended and stored at a lower temperature. Several field projects were constructed to verify and refine the engineering characteristics of the product and to develop specifications. FDOT specifies 12 percent recycled ground tire rubber (maximum nominal 40-mesh) by weight of asphalt cement in its open-graded surface mixtures and 5 percent (maximum nominal 80-mesh) in its dense-graded surface mixtures. The recycled rubber and asphalt cement can be blended by any means as long as the time, temperature, and other requirements are met.

The field research also included investigations into economics, environmental quality, and worker safety. Initial estimates indicated that for a continuing program, the cost increase for mix with asphalt rubber binder instead of asphalt cement would be approximately 15 percent. This figure has since been confirmed, but the increased cost has been offset by the improved performance of the finished product and the salvaging of tons of waste tires from landfills. Field research indicated no increase in the hazard to workers or the environment from asphalt containing ground tire rubber.

FDOT interacted with asphalt contractors, equipment manufacturers, and material suppliers throughout the approval process, facilitating a smooth transfer of the technology from research to field testing. For example, the study of environmental impacts and worker safety resulted from specific concerns raised by industry representatives, and incorporated their input. Specification development for ground tire rubber required significant input from the material's suppliers. The use of demonstration projects and involvement of the industry in field trials streamlined the transfer of the technology so that it took place simultaneously with the evaluation of the finished product.

Florida made a commitment to use ground tire rubber routinely for the applications identified as appropriate. Asphalt rubber binder containing recycled ground tire rubber in a spray application is also used for a crack-relief layer. A committed program allowed contractors, equipment manufacturers, material suppliers, and potential blending-service contractors to make long-term plans and investments. The result of the rubber recycling process is improved surface-course mixes and the reduction of waste from used tires in the state.

New Uses for Old Materials

Florida DOT has also developed specifications for glass and glass aggregates, recycled steel in reinforcing steel for concrete and I-beams, fly ash in soil stabilization applications, and fly ash in concrete. Specifications have been modified to accommodate recycled concrete pavement crushed into a standard coarse-aggregate gradation for pavement concrete. Limestone screenings are allowed, with exceptions, as fine aggregate when silica sand is not locally available.

Florida's successful programs have been the result of careful performance-based evaluations of materials that were not historically considered engineering materials. When a system is in place that recognizes the potential of waste material and provides for verification of performance through directed research and field trials, what was once considered waste can become a resource and a valued commodity.

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