New Uses for Old Tires:

Options to Reduce Waste and Stretch Public Works Dollars Overview

A key challenge facing local governments has been addressing waste tire disposal and recovery. Unlike most types of solid waste, waste tires cannot be simply landfilled without first being processed. This contributes to illegal dumping and the development of tire stockpiles. Discarded tires present a variety of hazards for the environment and public health, including providing habitat for disease-carrying vectors and creating the potential for fires at both illegal dumps and regulated tire stockpiles.

Within the last five years, the State of California has seen two of its largest tire stockpiles—located in Tracy and Westley—catch fire. These fires have raised concerns about the need to eliminate the existing stockpiles and to develop additional end uses for tires.

The state's tire problem is significant. Californians produce more than 30 million discarded tires annually, representing 1 percent of the municipal waste stream by weight. Another three million tires are exported from nearby states. Seventy-two percent of the 34 million tires are being diverted to end uses such as reuse, retread, crumb rubber, and energy recovery. The state must find end uses for the remaining 8 million tires, which are currently being stockpiled, illegally dumped, or shredded and landfilled.

> Localities can estimate that their generation of tires on an annual basis will be equal to their population. The weight may be estimated by multiplying the population by 20 pounds per tire. This provides the jurisdiction with a passenger tire equivalent; industrial and agricultural tires weigh significantly more.

Efforts to reduce tire disposal and increase recovery have been driven by two diversion mandates. The first is the Integrated Waste Management Act (AB 939, Sher, Chapter 1095, Statutes of 1989 as amended [IWMA]). The second is the Tire Recycling Act (AB 1843, W. Brown, Chapter 974, Statutes of 1989). AB 1843 originally established a $0.25 per tire fee used to fund the tire programs of the California Integrated Waste Management Board (CIWMB).

AB 1843 was aimed at reducing the disposal and stockpiling of tires by 25 percent within four years and recycling and reclaiming used tires to the greatest extent possible. The law was amended by Chapter 838, Statutes of 2000 (SB 876, Escutia) which raised the fee to $1.00 per tire and expanded the responsibilities of the CIWMB.

State efforts to recover tires create an opportunity for local public works departments. New uses for old tires are providing creative ways to reduce waste, cut costs, and improve the quality and safety of public works projects.

Tires can become an important part of local public works projects in three key areas:

- Use of rubberized asphalt in local road projects.
- Use of tire shreds and rubber products in other civil engineering applications.
- Use of crumb rubber products in playground renovations.

This model study presents a detailed analysis of two tire recycling options for local governments: rubberized asphalt (Los Angeles County), and civil engineering fill (the State of Maine).

The Tire Recycling Process

While this study is focused primarily on the development of innovative end use markets by local governments, they can play a role in each step of the tire recycling process.

Managing tires in the waste stream falls into three distinct phases: collection, processing, and end use. Local governments may be involved in one or more of these steps, but they are not usually involved in all three (that is, from collection through end use).

San Joaquin County has developed a comprehensive tire management program. The county established a tire amnesty program to collect old tires from the public. Staff contracted with a tire shredder to process the tires and then burned them at the local cogeneration facility in Stockton.

Collection

Collection presents the first challenge to dealing with tires. Collection is ongoing and is primarily the responsibility of tire dealers. Registered private haulers transport discarded tires to crumb rubber producers or other facilities for end use or disposal. Nevertheless, many tires may not get collected and are illegally dumped.

A local government may conduct an ongoing collection program, a one-time collection day event, an illegal pile cleanup, or a community cleanup program. An amnesty day program allows citizens to bring old tires (normally with a per-person tire limit) to a central drop-off location.

Processing

Depending on the end use, local governments will need to decide how to process the tires collected. For most tire management programs, this will entail working with a private company in the shredding or crumbing business. Shredding entails inspection for contamination (rocks, organics, bolts, and other metals), cleaning, debeading (pulling the steel bead from around the rim of the tire), and shredding.

The extent of the shredding process depends upon the desired shred size needed for a particular end use. The production of crumb rubber requires the extra step of granulating the small shreds to as small as 80 mesh size or as needed for the intended end use. In all cases, transportation of whole tires to the processor or site will be a factor to consider.

When the Davis Street Landfill in Alameda County closed and became a transfer station, the county's waste management authority—along with the hauler—turned the site into a materials recovery park. One of the tenants is a tire shredder/processor.

The proximity to the urban service area has allowed many local governments to work closely with the processor both in cutting costs as well as in providing a supply of shreds and crumb for local use. The processor offers a "close the loop" discount for localities that supply tires for processing and purchase crumb rubber or shreds for end use.

End Uses/Markets

New uses for old tires are providing some creative ways to reduce waste, cut costs, and improve the quality and safety of public works projects. The potential uses for waste tires are endless. The cost-effectiveness and the state of development for end use markets vary considerably.

Three primary end use markets currently exist for waste tires: energy recovery, retreading, and crumb rubber products. Civil engineering fill is another major—but currently undeveloped—use for tires in California. In addition, there are a variety of other small end uses for tires.

Energy Recovery. In 2000, the largest single end use of tires in the state was energy recovery, consuming approximately 5.2 million tires in cement kilns, energy recovery facilities, or co-generation facilities. Several cogeneration facilities around the state are permitted to burn tires. These facilities are the most economical since they typically do not charge a tip fee to accept tires.

The Modesto Energy (MELP) facility, located adjacent to the Westley tire pile, was the only facility in the state to burn whole tires to produce electricity. The facility had been burning approximately 6 million tires per year, but it has been forced to close operations due to the recent tire pile fire and the inability to compete economically under energy deregulation. Several cement kilns around the state are currently permitted to burn tires as a supplement to their coal use. These facilities charge to handle tires.

In addition, two coal-fired cogeneration facilities are using tires as fuel supplements. About 10 percent of the heat input can be provided by waste tires. The Air Products facility in Stockton combusts more than 1 million shredded tires annually.

Retreading. In 2000, retreading consumed approximately 2.4 million tires. Retreading tires can be one of the most cost-effective methods of diversion; however, only certain tires can be retreaded due to their initial construction or excessive wear. Truck or heavy equipment tires are best suited for this. The cost savings over virgin tires make the operation profitable for both the retreader and the consumer. Cost savings to the consumer can exceed one hundred dollars per tire. This is a particularly attractive option for fleet users.

Crumb Rubber Products. Approximately seven million tires were used in crumb rubber production in 2000, primarily for both paving and molded products.

- *Paving Applications*. A variety of State and local government agencies, including Los Angeles County and the California Department of Transportation (Caltrans), have proven that rubberized asphalt concrete is a significant and viable end use for tires.

Crumb Rubber Uses

paving materials * rail crossings * sound barriers
industrial flooring * sealant * shoe soles
carpet pads * playground mats * pond liners
conveyor belts * recycling bins
oil spill absorber * floating docks
wharf pilings and buffers
agricultural pipes * animal bedding * fencing

- *Molded Rubber Products*. At present this market is still in its initial development stage but it represents the greatest potential for value-added recycling. The CIWMB has issued grants to various private businesses and public agencies for pilot projects to fund the development and purchase of molded rubber products.
- *Soil Amendment*. Tests and demonstration projects have shown crumb rubber used as an additive to soil can increase soil permeability as well as oxygen flow.

Supporting Tire Recycling Through Local Public Works Projects

Local government public works departments can play a key role in supporting the development of new markets for tires.

Rubberized Asphalt

A key market for tires is the addition of crumb rubber to produce rubberized asphalt concrete (RAC). Caltrans began its use of rubberized asphalt concrete in 1980. Between 1980 and 1998, Caltrans used a total of 2,458,930 tons of RAC in every one of its regional districts. Based upon the formula developed by the Rubber Pavements Association, this translates to the use of 4.5 million discarded tires.

Caltrans estimated that it is currently using RAC on 10 to 12 percent of its projects. The Rubber Pavements Association estimates that Caltrans could use RAC on up to 40 percent of all paving projects.

Los Angeles County has been the leader among local governments in the use of RAC. The county established, with the assistance of the CIWMB, the Southern California Rubberized Asphalt Concrete Technology Center to promote the use of RAC. While the county's efforts are focused in Southern California, the center answers questions from local governments throughout the state.

Use of tires in rubberized asphalt concrete can produce significant cost savings and diversion potential for local paving and road maintenance operations. While the cost savings will vary based on the project, the Southern California Center has produced design examples with cost savings of $22,852 per mile for a simple asphalt overlay and

Application of rubberized asphalt concrete in Sacramento.

savings of $170,776 per mile for roadway reconstruction. Based on LA County's use of rubberized pavement since 1993, RAC diverts approximately 2,000 tires per lane mile.

The use of rubberized asphalt provides a variety of benefits, including:

- Longer lasting surface (50–100 percent).
- Resistance to rutting and cracking.
- Reduced road noise (50–80 percent).
- Less buildup of road surface.
- Reduced cost of project and/or ongoing maintenance expenses.

In addition to RAC, local governments may also consider the use of rubberized emulsion aggregate slurry (REAS) in street resurfacing projects. Although REAS is more expensive per lane mile, LA County's experience shows it can divert almost 80 tires per lane mile. REAS also provides a number of other benefits, including increased performance and extending the roadway's lifespan.

While RAC/REAS provides a number of benefits, it may not be appropriate in every application. The use of RAC/REAS should be determined on a case-by-case basis taking into account the uses of the roadway and its initial condition for compatibility.

Staff should work with city administrators and contractors to modify current practices to ensure that the use of RAC is considered. In addition, local governments can request that Caltrans use rubberized asphalt on projects within their jurisdiction. Construction contractors should be linked up with the tire processors to ensure that the bids are accurate. Special attention should be paid to projections of volume vs. weight used and the timing of use during construction.

To help local governments in considering its use, RAC is now specified in section 200 (page 98) and section 200 (page 258) of the "Green Book" (or Standard Specifications for Public Works Construction) used by local government throughout California.

The County of Santa Clara has established a resolution on the use of rubberized paving materials as part of its open bidding process. Contractors are required to submit bids that contain options using tire-derived paving materials. The county then can assess the up-front costs and performance projections, as well as any special factors that may effect the determination to use recycled materials.

The City of Thousand Oaks has used RAC to pave more than 130 miles of roadway since 1992 using 1.3 million tires. Recent costs for RAC have averaged $49 per ton. This includes application during day and night periods, as required by the urban nature of Thousand Oaks. The city found that the improvements of increased skid resistance, reduced road noise, improved riding qualities, and imperviousness to water have made the use of RAC cost-effective and desirable over traditional asphalt concrete.

Communication with public works departments and jurisdictions that have experience with paving and civil engineering application can help address local concerns or specific needs. Jurisdictions with RAC/REAS experience include the following cities and counties:

- Calabasas
- Costa Mesa
- Culver City
- Garden Grove
- Huntington Beach
- Richmond
- San Clemente
- Santa Monica
- Thousand Oaks
- Orange
- Sacramento
- Santa Clara
- San Francisco
- Los Angeles

In an effort to document the use of RAC, the CIWMB and the California Department of Transportation (Caltrans) have established a rubberized asphalt concrete pavements review team. Members included private contractors working in supply, production, and application of tire-derived paving materials. The team observes and assesses the performance of rubberized paving materials. The goal is to develop a database as well as experience and technical expertise in the rubberized paving field.

The preliminary report of the team found that 101 out of 113 projects were successful. Of the 12 projects rated fair or poor, most members of the team believed that the failures would have been greater with traditional asphalt concrete. These failures may also have been caused by using poor aggregates.

Civil Engineering Applications

The use of shredded tires as fill in civil engineering applications is a major potential market for waste tires, but it is currently only in the demonstration phase in California. In 2001, the CIWMB sponsored a project in the San Francisco Bay area at a new interchange on Interstate 880. Six hundred thousand shredded tires were used as lightweight fill for a highway on-ramp built on unstable bay mud.

Shredded tires have an enormous potential to be used as lightweight fill in civil engineering applications, and they can replace other conventional lightweight fill such as expanded foam. Besides providing a major end use of tires, tires used as fill provide improved permeability and greater insulating properties than traditional fill materials.

Civil engineering fill has been limited to a few pilot projects in California (Humboldt County and Chico, in Butte County); however, the CIWMB is strongly supporting the development of this market. The State of Maine has been a major user of tires for civil engineering fill, making it the predominant use for its abatement piles.

This market can have a significant impact on discarded tire use. Individual projects can use several hundred thousand tires.

Civil engineering applications require that tires are shredded, and minor adjustments to project designs may need to be made. The performance of the material can exceed current options available and can substantially reduce costs associated with lightweight fill.

Examples of civil engineering projects include the following:

- Overpass fill.
- Levee slurry wall (mix with concrete).
- Retaining wall fill.
- Roadway base fill.
- Bridge abutment fill.

In addition to fill applications developed by Maine, here are some other potential civil engineering applications:

- The CIWMB has guidelines regarding use of tire shreds in landfill applications. These uses include leachate drainage material, final cover foundation layer, operations cover, and gas collection layer. In Virginia, tire shreds have been used for septic tanks. Specifications are available for septic tank leach fields in an average four-bedroom home using 1,350 tires per system.
- The usage of tires in Virginia presents a viable option for rural areas. Depending on the contamination limits and the ability to store a stockpile of shreds, a local government could make available the shreds as a fill for the residents or for private contractors.

The CIWMB is conducting a demonstration of tire shreds in leach fields at a highway rest stop along Interstate 5. The project was constructed in 1999–2000 and is currently being monitored.

Efforts to replace playground equipment to achieve compliance with State and federal laws provides an excellent opportunity to showcase new uses for recycled tires. (Source: CIWMB)

Playground Equipment

Recent State and federal laws have required schools and public agencies to renovate playground equipment in order to meet new safety and accessibility standards.

In an effort to encourage the development of new uses for tires, the California Legislature passed the Playground Safety and Recycling Act (AB 1055, Villaraigosa and Keeley, Chapter 712, Statutes of 1999). This law established a $2 million matching grants program to replace and upgrade public playground equipment. The act requires 50 percent of the funds be used to purchase equipment made from recycled materials such as tires.

The City of Torrance took part in a public/private partnership program with Sears, Roebuck and Co. In 1997, the city received 10,000 pounds of recycled rubber resurfacing products for several local schools as part of the store's R.O.T.A.T.E. (Recycling Old Tires Aids The Environment) program.

The program includes special tire collection events. A local processor turns the tires into crumb rubber, and the R.O.T.A.T.E. program supplies products at no cost to the locality where the tires were collected. Los Angles County helped to coordinate the program and supplied curriculum materials on tires for elementary students. This program reached more than 500 students.

The City of Garden Grove is an example of a community that has used tires in a variety of ways. The city used 22,500 tires in projects, receiving a total of $195,000 in grant assistance. Tire projects included the following:

- Purchase of two railroad grade crossings using 3,500 tires and a $50,000 grant. The railroad installed the crossings.
- Four playgrounds were resurfaced using grants of $25,000 and $20,000, and recycling 10,000 tires.
- The city received a $100,000 grant for the use of resealing slurry (REAS) on local road projects using almost 9,000 tires.

Costs, Economics, and Benefits

Costs associated with tire management programs vary depending on the requirements of the jurisdiction. Costs generally fall into the categories of collection, processing, and end uses. Grants to underwrite tire program costs are available from the CIWMB.

Collection and Processing Isn't Free

Collection costs depend on the type of program operated. Average costs for collection programs range from $1.82 to $2.26 per tire, with costs per tire decreasing as the number of tires handled increases. Factors that will affect costs include:

- Type and duration of collection days.
- Establishment of a permanent drop-off site.
- Transportation to processor.

Processing costs are typically carried by the private sector and passed on in the cost of the end-use product. Crumbing a typical tire costs around $2.40 each. Shredding costs will depend on the size and preparation requirements such as elimination of wire beads.

Used Tires Can Save Public Works Dollars

End-use costs to the local government depend on the type of use. In some cases tires are not only cost-effective, they dramatically reduce costs for public works projects or local government needs.

Crumb rubber from waste tires used in paving projects in most cases can actually cut the costs of projects in which they are used. Savings occur due to the need to place less asphalt concrete to meet design specifications, thereby offsetting the expenses associated with tire rubber purchase.

The result is a net decrease in public works expenditures for the project, with a possible initial cost saving of between $22,000 and $170,000 per lane mile. Ongoing savings from reduced maintenance and a longer replacement life cycle add dramatically to the initial savings.

Rubber mats or molded rubber products typically are comparable in cost to rubber products that have no recycled content. As a substitute for other non-rubber products, costs may be higher. But often the product will last longer or have other benefits that can offset the additional expense.

Civil engineering projects in Maine have shown that tires can be cheaper than typical lightweight fill; however, no study or analysis exists to quantify those savings.

CIWMB Grants Are Available

The CIWMB offers grants to local governments for tire recycling covering collection programs, use of paving material, and playground/track covers.

For collection programs the CIWMB provides matching grant funds for amnesty days, public education, staff time, and some transportation and processing costs. CIWMB has provided grants to local government and school districts for the purchase of rubberized playground mats. This program is being expanded to $2 million annually ($50,000 maximum per project) as a result of AB 1055.

Rubberized asphalt grants are available for determining the potential use, quality assurance and control, and costs associated with rubberized asphalt. Grants from the CIWMB are available through the Los Angeles Rubberized Asphalt Technology Center on a first-come-first-served basis and are based upon the tonnage of material used.

Local Government Challenges and Opportunities

A key challenge in tire recycling is communication between all stakeholders involved in a project. This would include developing a strong working relationship with both tire shredders and with public works contractors.

While a local government may have a strong desire to see tire-derived materials used, it is the private contractors who will be the key in both preparing them for use as well as applying them in most projects.

Most programs are public/private partnerships for several reasons:

The equipment costs associated with shredding, crumbing, and blending typically prohibit local governments from setting up a cost-effective in-house program combining all three aspects.

Many local governments do not have the immediate volume of work to use their present supply of waste tires. Contamination at long-term stockpiles can make the tires unacceptable for some uses, and the expense of stockpiling can make their use no longer cost-effective.

Private contractors are often better equipped to process and supply tires for construction projects to be used by a number of jurisdictions.

Besides considering the use of tires in paving projects and civil engineering applications, there are a variety of other opportunities for local governments to use their purchasing power to support increased tire recovery and end use, including the following:

Local governments can promote the use of retreaded tires on fleet vehicles. Local government motor pools and private operators of fleet vehicles can be encouraged to develop plans to focus both maintenance and purchasing routines to take the greatest advantage of this option.

Local governments can support the purchase of new tires containing recycled content. Michelin and Continental General Tire currently produce a tire that contains 5 percent recycled content. Ford has been a leader in supporting their use, making them standard equipment on the Windstar van and the F-150 pickup.

Local governments can support the purchase of recycled rubber products, particularly in the area of mats and sport floorings. As a result of new State laws, schools and local agencies are already replacing playground equipment. The CIWMB can award grants to offset the additional cost of used tire-derived products.

Tips for Replication

- Ensure communication among stakeholders, including processors and paving contractors.
- Make sure rubberized asphalt is considered as an option, but recognize it may not be appropriate in every application.
- Provide adequate monitoring and evaluation.

Case Study: Los Angeles County Use of Rubberized Asphalt

Overview

The County of Los Angeles began limited use of rubber in asphalt in the 1970s. In 1985 the county used a 1½-inch layer of RAC to resurface a roadway that is holding up exceptionally well to this day. Federal regulations that had required the use of recycled rubber in paving projects under the Intermodal Surface Transportation Efficiency Act of 1990 served as an incentive for LA County in the use of RAC.

Since 1992 the county has been using both RAC and rubberized emulsion aggregate slurry (REAS) in its highway and street resurfacing products respectively. RAC use by the county since 1993 has resulted in diversion of more than 1.2 million tires, paving close to 600 lane miles (a diversion of 2,000 tires per lane mile). The county now uses RAC on 75 percent of its highway resurfacing projects, using funds for road construction generated by gasoline taxes.

Blending crumb rubber with asphalt and aggregate under specific conditions produces RAC. A crumb rubber producer grinds the waste tires into crumb rubber. The crumb rubber is then blended with the asphalt and aggregate in a preset formula at the asphalt plant under the “wet” process and shipped to the construction site for use. A blender unit is needed at the asphalt plant.

REAS is defined as crumb rubber blended into asphalt emulsion at ambient temperature and used as slurry on road surfaces. Los Angeles has used REAS since 1993, paving more than 1,330 lane miles. This has resulted in diversion of 104,000 tires (at 78 tires per lane mile). REAS projects have been similarly paid for using gasoline taxes.

To support the use of RAC, LA County and the CIWMB jointly created the Southern California Rubberized Asphalt Concrete Technology Center (SCRACTC). The center serves as a professional outreach operation and as a clearinghouse for information regarding crumb rubber pavement use.

Program Characteristics

The LA County Department of Public Works operates the RAC/REAS program as part of its ongoing road construction and maintenance operations.

Los Angeles requires the use of RAC/REAS in paving projects, as appropriate. Staff members assess the projects that are suited for use of RAC/REAS materials, and contractors are asked to submit bids accordingly. Public works staff monitors both the blending and the application process to ensure project success.

This coordinated effort by the public works staff is the primary reason for LA County’s success in using RAC/REAS to divert tires from landfills. The SCRACTC assists local governments in making RAC use determinations. The center, on behalf of CIWMB, provides grants for both roadway deflection testing and quality assurance control monitoring. These grants are given first to jurisdictions that have not used RAC before, then to others.

Costs, Economics, and Benefits

LA County requires large amounts of paving material in ongoing public works projects. The county has saved initial construction funds by using RAC, and administrators project substantial long-term savings in maintenance costs.

Two examples of cost savings are shown below:

Project Design Example # 1
Testing indicates a 4" overlay o f conventional asphalt (AC) is needed to resurface the roadway.

Conventional Asphalt
1,584 tons @ $ 30/ton = $ 47,520
Pavement preparation = $ 7,000
Total cost = $ 54,520 per lane mile
or
2" RAC overlay
754 tons @ $ 42/ton = $ 31,668
(Note: RAC weighs 5 percent less than AC)
Savings per lane mile = $22,852

Project Design Example # 2
Testing indicates that the roadway must be reconstructed to a gravel equivalent of 26.

Reconstruct With Conventional Asphalt
Excavation of old roadway
4,107 cu yd @ $25/cu yd = $102,675
Crushed aggregate base
3,324 cu yd @ $20/cu yd = $ 66,480
Asphalt concrete
1,584 tons @ $30/ton = $ 47,520
Total cost = $ 216,675 per lane mile
or
Resurface With Cold Mill and RAC
Cold mill aggregate
63,00 sq. ft. x $.10 = $ 6,336
Rubberized Asphalt Concrete
942 tons @ $42/ton = $39,564
Total cost = $ 45,900 per lane mile
Savings per lane mile = $170,776

Source: SCRACTC

The county found that RAC has a number of advantages over traditional asphalt concrete:

- Cost-effectiveness.
- Longevity.
- Increased skid resistance.
- Decreases in road noise (50–80 percent).
- Lower maintenance requirements.
- Better color contrast for striping.

Although REAS is more expensive per lane mile, it also provides a number of benefits:

- High skid resistance.
- Long-lasting color contrast for striping.
- Extension of the roadway's life span.

Los Angeles has funded the use of both RAC and REAS directly through the use of gasoline tax revenue.

Local Government Challenges and Opportunities

The historic challenge in using RAC was that the technology/process was patented, and patent fees drove up costs. In 1992 the patents expired, putting RAC in the public domain.

The next challenge for LA County is to convince public works officials of the benefits of using a "new" paving material. The greatest opportunity in using RAC/REAS is the potential for diversion of tires from landfills (up to 2000 tires per lane mile).

Tips for Replication

- Ensure adequate stakeholder awareness and education.
- Promote communication between project engineers, local public works officials, private contractors, and crumb rubber producers.
- Understand the material processing requirements and application procedures—this is essential to a successful project.
- Provide adequate monitoring to ensure successful application.
- Conduct follow-up monitoring and testing of RAC/REAS paving projects.
- Recognize that RAC/REAS may not be suitable in every application.

Northern California RAC Center

The County of Sacramento opened a rubberized asphalt technology center in 2000. The center functions on the same model as the SCRACTC and assists local governments in Northern California with RAC use.

Case Study: State of Maine's Alternative Fill Programs

Overview

The State of Maine first began to explore the use of tires for transportation projects as a paving material in the early 1990s. Federal regulations targeting recycled tire use drove the effort. Finding the costs at the time to be prohibitive and the potential for use limited, the state began to look for another option.

Use of tire shreds in civil engineering fill on Route 9, Days Hill, Maine. Source: Dana Humphry.

Professor Dana Humphrey, a professor of civil engineering with the University of Maine, came up with the option of using tire shreds as an alternative to lightweight clean fill. The use of tires—at that time untested—could potentially save money as well as out-perform the other materials then being used as fill.

Professor Humphrey began working with the Maine Department of Transportation (DOT) and the Maine Department of Environmental Protection (MDEP). Representatives from these agencies formed the stakeholders group.

As projects were proposed, they were evaluated for the use of tires as applicable and where study would be possible to assess the value of tire shreds as a clean fill option. From 1993 to 1998, Maine

DOT used 920,000 passenger tire equivalents in five fill projects. The MTA used 1.2 million tires in a single project in 1997–98 and plans to use a similar amount in a project in the summer of 2000.

Lightweight fill is now the primary use for tires removed from Maine's abatement piles; however, it is not the primary use for the state's current tire flow. More than 5 million passenger tire equivalents (PTE) are burned as fuel in three paper mills, making this the primary use. In addition, a total of 1.8 million tires were used as the operations layer in two landfills from 1997 through 1999.

Program Characteristics

The management of Maine's tire diversion program falls into two distinct parts. The collection and stockpile management is coordinated by the MDEP, which permits both haulers and the tire chippers (shredders). Maine's tire management program assesses a fee of $1.00 per tire for all after-market tires; these funds go into the general waste management account for various programs. Tires are accepted at tire dealers and transfer stations typically for an additional fee of between $1.00 and $5.00.

The tire fee covers the cost associated with handling and transportation of the waste tires to two tire chippers, one in Maine and the other in Massachusetts. Maine does not permit the landfilling of whole or shredded tires and exports only a small fraction to a cement kiln in the Canadian city of Montreal.

Maine's Civil Engineering Project Examples

1. Town road in Richmond: 20,000 tires in 600-foot road.
2. 2-lane secondary state highway in North Yarmouth: 100,000 tires in 400 feet of road.
3. 4-lane primary highway in T31MD: 200,000 tires in 400 feet of road.
4. Highway embankment in Portland: 1.2 million tires.

The end use of the tire shreds in roadway applications falls under the direction of Maine's transportation agencies (MTA, MDOT, and municipalities) that incorporate the use of shreds as part of the bidding for the construction project. Shreds are specified for fill in a project, and the tire chippers supply them to the site.

The chips are processed to meet specific requirements including chip size, minimization of crumb rubber, and the mitigation of steel belts and wires for the project. Due to the specific characteristics of tire shreds, they have been used as fill in projects where they were desired for their lightweight, permeable, or insulating properties. The projects using tire shreds include drainage layers under roadways, frost barriers, lightweight fill for embankments and retaining walls, and highway edge drains.

In most cases, a contractor supplied tire shreds (as a subcontractor) to the contractor building the road. Local governments can request that contractors bidding on projects with fill requirements prepare a bid option using tire shreds as applicable.

Having this as an option—but not a requirement—is desirable. The availability of tire shreds, as well as the ability of the shredder to prepare the shreds to specification, may be an issue. This should be carefully and completely understood to avoid unnecessary and costly delays.

In cases where a locality has a tire stockpile on hand, the acceptability of those tires for the project is the primary consideration. Both the shredding contractor and the construction contractor need to assess the condition of the tires for contamination. Transport and shredding will be the determining factors in the cost-effectiveness of tire shreds for the project.

Costs, Economics, and Benefits

Funding for the State of Maine's tire program come from a variety of sources. Ongoing collection of tires is paid for by a combination of the tip fee charged by the retailer and the revenue for selling the final product. Non-state funds are involved.

Collection of tires in abatement piles comes from MDEP's general waste management fund, special bonds issued specifically for tire pile cleanup, and the party responsible for accumulating the tire pile.

Funding for the assessment of tire shred use, as well as the follow-up testing to monitor the quality of work, has been provided by MDEP and the transportation departments on a case-by-case basis.

Funding for the actual use of the shreds comes from Maine's road construction funds. The use of shreds has actually resulted in savings for the fund. The exact amount, however, could not be determined.

The running average for costs associated with the purchase and placement of the shreds were approximately $38 per ton or $27 per cubic yard. These costs have declined as both contractors and public works officials have become more familiar with tire shred use. The cost for the tire shreds transported to the sites ranged from $12 to $30 per ton and placement from $5 to $8 per ton.

The use of tire shreds in civil engineering projects is economical. In most cases the cost of the tire shreds was less than that of comparable materials available on the market. Tires exceed the performance of the other available materials for most uses.

The primary expense for Maine has been in both the education of its civil engineering community and in the technical studies done on the projects. The primary benefit of the use of tire shreds has been that Maine now has an end market for the remediated tires from abatement piles. In addition to saving landfill space, Maine has improved the engineering performance of the projects that required clean lightweight fill. The state has also cut costs associated with the use of fill.

Challenges and Opportunities

The primary challenge was in determining whether or not tires could be used in the role of fill. Issues included settlement of the fill material over time and ability to handle tire shreds with standard equipment. Other factors included the performance of the shreds regarding frost penetration, exothermic reactions, and interaction with other construction materials.

Despite all of Maine's concerns, tire shreds met or exceeded the standards. Maine closely studied each project and conducted exhaustive testing, gaining valuable insight into the use of shreds. With regard to exothermic reaction, it was noted that caution should be taken.

Guidelines to limit heating of tire shred fills as given in ASTM D6270 "Standard Practice for Use of Scrap Tires in Civil Engineering Application" should be followed. The tire fill should be separated from the surrounding soil by a geomembrane. It should not be exposed to the surface (free oxygen flow), and both crumb rubber particles and excessive exposed steel should be kept to a minimum.

While traditional equipment can be used, the exposed steel in the tire shreds caused flat tires for the construction vehicles. Tracked or solid wheel vehicles are recommended for application.

Tips for Replication

- Purchase tires by weight. This ensures that both the contractor and the site crews have better figures to calculate costs and delivery schedules.
- Ensure that you have a supply of tire shreds at the site adequate to keep up with the pace of work. This usually requires establishing a site stockpile prior to intended use.
- The shred producer will typically have a fixed volume at which they produce shreds or can transport them to the site. Project crews will apply tire shreds at a rate that typically exceeds the subcontractor's ability to supply them to the site. Note that piles consisting of more than 500 tires must be permitted by the CIWMB.
- Remember communication. Design engineers, shred suppliers, and site contractors all need to understand the behavior of the material as well as its proper application to ensure success and to stimulate future use of tire shreds.

References

CIWMB Publications

Many CIWMB publications are available on the Board's Web site at: www.ciwmb.ca.gov/Publications/. To order hard copy publications, call 1-800-CA-Waste (California only) or (916) 341-6306, or write:

California Integrated Waste Management Board
Public Affairs Office,
Publications Clearinghouse (MS-6)
1001 I Street
P.O. Box 4025 (mailing address)
Sacramento, CA 95812-4025

"Overview Report on California's Waste Tire Program," 1998, Pub. #540-98-007.

"Tires as a Fuel Supplement: Feasibility Study," 1992, Pub. #401-93-001.

"Market Development Status Report: Tires," 1996, Pub. #421-96-067.

"California Waste Tire Program Evaluation: Final Report and Recommendations," 1999, Pub. # 540-99-006.

"Waste Tire Program 2000 Annual Report," Pub. #620-01-006.

Other Tire Resources

"Civil Engineering Application of Tire Shreds," Dana N. Humphrey, Ph.D., professional engineer, workshop syllabus, 1999, University of Maine.

Sacramento County RAC Noise Study, 1999, Sacramento Division of Transportation.

Contacts

CIWMB Tire Program

Rubberized asphalt concrete and energy recovery from tires, Nate Gauff, (916) 341-6686.

Civil engineering application, Stacey M. Patenaude, (916) 341-6418.

Crumb/molded rubber products, Boxing Cheng, (916) 341-6434.

Playground/sport mat grants, Linda Dickinson, (916) 341-6437.

Cleanup grants, Diane Nordstrom, (916) 341-6448.

Local government enforcement grants, Dave Volden, (916) 341-6433.

For information on CIWMB tire grants and loans, see www.ciwmb.ca.gov/Tires/Grants/.

Other Programs

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Credits and Disclaimer

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The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, Flex Your Power and visit www.consumerenergycenter.org/flex/index.html.