

THE USE OF  
DISCARDED TIRES AND RECLAIMED RUBBER  
IN  
HIGHWAY CONSTRUCTION AND MAINTENANCE

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## 1.0 OBJECTIVE

Due to the mounting problem of disposing of used automobile and truck tires, environmental agencies — at both the state and federal level — are seeking alternative, innovative means of using these materials, including possible applications in the field of highway construction and maintenance.

This report presents a synopsis of the state-of-the-art regarding the use of tires and reclaimed rubber in highway applications and outlines some of the technical and economic issues which must be resolved prior to any widespread use of scrap rubber materials by the New Jersey Department of Transportation.

## 2.0. BACKGROUND

Disposal of discarded automobile tires is a nationwide problem which has reached epidemic proportions in recent years. In New Jersey alone, some seven million auto tires must be disposed of each year.

Historically, auto tires were either incinerated, landfilled, or retread. pollution regulations have since halted the incineration of tires due to the noxious fumes generated during combustion. More recently, landfill operators have begun to refuse truckloads of discarded tires or to charge exorbitant sums to accept them (up to \$8 per tire) because the toroidal shape of the tire causes it to float to the top of the landfill, creating an unstable condition. If the tires were shredded or ground, landfill operators would probably begin to accept tires again at a reasonable price, but this would be a temporary solution at best since landfills are becoming increasingly unpopular as a waste disposal alternative hence, landfill space increasingly unavailable. In the past, a significant number of used auto tires were retreaded and/or reclaimed, but this reportedly is no longer cost-effective. The New Jersey Department of Energy estimates only 10% of used auto tires are reclaimed, leaving 6.3 million tires to accumulate each year in New Jersey.

The tire disposal problem has become more obvious each year; the public's frustration with the problem has led to disposal in discrete, illegal dump sites, roadsides, embankments, and non-patrolled creeks and forests.

The New Jersey Department of Transportation, as a public agency charged with the maintenance of many miles of roadways, embankments, interchanges, rest areas and other sites which are likely receptors for discarded tires, is obviously interested in encouraging the development of environmentally sound, aesthetically acceptable means for disposing of used tires. More importantly, the Department is interested in realizing any of the reported benefits of incorporating scrap rubber in highway construction. To this end, it has explored several suggested applications through laboratory and field tests and has maintained a continuing review of reports and data from other agencies.

Recently, an action by the federal Environmental Protection Agency (EPA) has provided additional impetus for the Department to investigate the potential uses of tires/reclaimed rubber. The EPA has indicated that, in the fall of 1985, it intends to promulgate a procurement regulation which would specifically require that asphalt rubber materials be considered as an optional material in paving contracts. While the details of the proposed rule are presently unknown, the EPA guidelines apparently would allow an 18-month implementation period, during which time transportation departments would be required to revise their design guidelines and specifications to insure that asphalt materials containing scrap rubber are allowed "except where technically or economically inappropriate". (The EPA's proposed approach here is apparently quite similar to that it adopted in dealing with the use of another waste material -- fly ash -- in concrete.) Clearly then, it is important that the Department determine under what conditions use of asphalt rubber is "technically or economically appropriate".

As a result of research conducted by various transportation agencies, five general categories of scrap rubber use in highway applications have been identified:

1 Perhaps the most common use is in paving mixtures. These applications include the use of rubber-modified bituminous surfacing, crack-control bituminous interlayers, and chip seals. In each of these applications, the general objective of adding rubber is to increase the flexibility of the pavement and, hence, to retard surface cracking.

2) A second type of application involves the use of reclaimed rubber in crack and joint sealants. Because of the relatively low volume of sealant presently used in New Jersey, this application does not have great potential as a means for economically using reclaimed rubber.

3) Ground or shredded rubber has been used as a mulch material, soil conditioner and slope stabilizer. Little work has been accomplished in these landscaping-type applications of late, probably because the costs are extremely high and the final product is not aesthetically pleasing.

4) Tire carcasses have been used as building blocks for safety appurtenances and structures, such as in inertia barriers and in retaining walls. Recently this area of study has shown much promise.

5) A fifth potential area of use for scrap rubber -- albeit, an untried one -- is to incorporate shredded tires into soil masses for embankments. This application may be technically and economically feasible on borrow jobs.

### 3.0 DISCUSSION - HIGHWAY APPLICATIONS

#### 3.1 PAVING MATERIALS

3.1.1 Rubber-Filled Bituminous Concrete: Two general procedures been used to incorporate reclaimed rubber in bituminous concrete surfacing. In the first of these, a small percentage of granulated rubber replaces a portion of the aggregate in the bituminous mix. This product -- referred to as "rubber-filled" bituminous concrete -- requires a great deal of laborious mix design work, as well as, additional asphalt cement and increased mixing time to insure that the rubber granules are completely coated and uniformly blended into the mixture. The claimed advantages of the product are reduced susceptibility to cracking and a "self-deicing" property.

Rubber-filled mixes are relatively new in the United States and are the subject of ongoing studies by a number of transportation agencies, including New Jersey, Utah, Colorado, and Alaska. The Texas Transportation Institute (TTI) has studied rubber-filled systems. Although their conclusions are qualified (... "few of these types of applications were observed, therefore, general conclusions regarding performance are not possible"); TTI did note that "the majority of projects indicating improved performance contained finely ground reclaimed rubber at 1% by total mix weight".

New Jersey's experience with rubber-filled systems began in August, 1984 with the construction of a 600-ton test section of a proprietary surface mix known as "Plus Ride" which contains 3% granulated rubber. Eighteen tons of rubber granules were consumed, which is roughly equivalent to 2,600 discarded

In this experimental installation, constructed on Route 41 in Cherry Hill, the performance of Plus Ride will be compared to that of four other experimental asphalt additive-modified mixes and a control (conventional) mix. Although it is obviously too early to draw any definitive conclusions regarding

the overall performance of Plus Ride, some initial problems with skid resistance and roughness have been observed.

The cost of this type system appears prohibitive at the present time. That is, the in-place cost of the Plus Ride mix on the Route 41 experimental project was \$56 per ton, which is about \$30 per ton more than the current average price of the Department's conventional surfacing. Assuming the most optimistic outcome for the Plus Ride mix in the research study -- that is, that its performance warrants adoption as the Department's standard surfacing mix -- at current levels of usage (approximately one million tons of bituminous binder and top course per year), the Department would incur about \$30 million in additional construction costs per year for bituminous surfacing. This would consume some 30,660 tons of scrap rubber, equivalent to 4.4 million tires. If 1% rubber were used in the mix, the additional construction costs would amount to \$10 million and 1½ million tires could be used. This would be a very high cost to pay and one would question the wisdom of such an expenditure, unless major performance benefits were realized.

To date, research on rubber-modified mixes has concentrated on their use in surfacing mixes, which constitute the upper 2 to 3 inches of the pavement structure. Another possible area of use for rubber-filled systems would be in the lower (bituminous stabilized base) layers, which can constitute as much as 6 inches of the total pavement structure. However, if the cost-effectiveness of rubber-modified surfacing mix is uncertain, this would be even more the case for bituminous stabilized base. That is, since these underlying layers are not generally the source of the cracking problem which the rubber-modified mix seeks to control, the addition of scrap rubber here would have to be regarded as a high cost filler material, rather than as a mix enhancer. Tests would need to be conducted to ensure that a rubber-filled base course mix would not adversely effect overall pavement performance.

In addition to their uncertain performance and high cost, another issue which remains to be resolved with regard to rubber-filled systems — indeed, any rubber-modified mix — is the extent to which the presence of rubber may affect future recycling efforts. The Department is strongly committed to bituminous pavement recycling and, for example, routinely permits certain bituminous paving courses to be composed of as much as 50% recycled asphalt pavement. There is at least some question as to whether a rubberized bituminous pavement could be safely recycled, particularly through the drum-mix type plants which are increasingly being used in this state. That is, although the heating flame in an asphalt plant is at least partially shielded, there would appear to be at least some potential fire hazard when a recycled mix containing rubber is processed through the plant. The heated rubber also might present an emissions problem. Obviously, this issue must be resolved before any serious commitment is made to use scrap rubber in New Jersey pavements.

3 .2 Asphalt Rubber Paving Mixes: The second general technique for using reclaimed rubber in bituminous surfacing is to use it in the form of a blend with the asphalt cement binder, as a so-called "asphalt rubber"

Asphalt rubber is produced by adding 10 to 30 mesh-size tread rubber grindings and buffings to asphalt cement, dispersing and heating the mixture for an hour at 400°F. This modified binder material is used much the same as any asphalt cement. In the usual application, rubber constitutes 25% of the total weight of the asphalt/rubber blend. Asphalt rubber of this type has been used extensively in chip seals, stress-absorbing membranes and interlayers, and in joint and crack sealants. Also some research work has been conducted using asphalt rubber bituminous concrete.

A great deal of asphalt rubber research has been conducted, but highway agencies have come out with a commitment in the form of a standard specification for asphalt rubber. Texas seems to be taking the lead in this work, using 20,000 tons in 1985. The city of Phoenix has had some asphalt rubber chip seals in service for about 15 years and is very satisfied with their performance.

The Department does not use chip seals because of the prevailing high traffic volumes on state highways. Chip seals do not perform well under high traffic. However, our counties and municipalities, who have jurisdiction over lower volume roadways, do use chip seals and an asphalt rubber type could conceivably be used by these agencies. For a chip seal, asphalt rubber is usually applied to the prepared surface of the roadway at approximately 0.5 gal/sq. yd. The loose aggregate (chips) is then spread and rolled in. For one lane mile of roadway, approximately 3525 gallons of asphalt rubber would be used, containing 25% tread rubber, at a cost of approximately \$2500 more than standard designs.

Much work has been conducted using asphalt rubber stress-absorbing membranes and interlayers to control cracking in the western states. These states are reported to have severe cracking problems in bituminous pavements. In New Jersey, cracking of bituminous pavements is not considered a major problem; however, reflection cracking of bituminous overlays placed over portland cement concrete is commonplace. New Jersey utilizes a unique expansion joint design which permits relatively large movements between concrete slabs, ultimately resulting in reflection ("mirror") cracking of overlays. Rubber membranes would not be expected to function well under these conditions. For example, the FHWA has noted that "...transverse longitudinal joints in Portland cement concrete pavements will tend to reflect through asphalt rubber interlayers and thin asphaltic concrete overlays." result, asphalt rubber membranes and interlayers have not been considered for

use in New Jersey. Another factor here is that the Department has developed an alternate solution to the reflection cracking problem (see Section 3.2.2).

### 3.2 SCRAP RUBBER CRACK AND JOINT SEALERS

Hot-poured, elastomeric type joint and crack sealants have been used by highway agencies for many years. The elastomeric portion of these sealants may be composed of granulated, reclaimed rubber or of various virgin materials, i.e. plasticizers, polymers, and fillers

3.2.1 Crack Sealants: Crafcoc, Inc. manufactures reclaimed rubber type crack and joint sealants which cost approximately \$0.25 per pound more than the conventional type sealer currently in use in New Jersey. For fiscal year 1985, the Department's usage of crack sealant amounted to 169,258 gallons, at a material cost of approximately \$0.87 per gallon (\$0.11 per pound). If a reclaimed rubber type sealant were used in place of our current material, the Department's crack sealing program would consume some 150 tons of scrap rubber per year. This relatively minor amount (less than 1% of the available supply of discarded tire rubber produced in New Jersey each year) would do little to alleviate the problem of used tire disposal in the state, while the additional cost to the Department would be approximately \$338,000. This additional cost would represent an increase of some 38% over our total in-place cost of \$898,000 for fiscal year 1985.

3.2.2 Joint Sealants: At present, very little joint sealing work is done in New Jersey each year -- in 1984, Department maintenance forces placed only 33 joint-miles of sealant -- using only 10 tons of sealant material. If reclaimed rubber type joint sealants were used, only 2 tons of scrap rubber would have been consumed

However, research conducted recently in New Jersey dealing with alleviating reflective cracking in bituminous overlays on portland cement concrete may ultimately result in an expanded joint sealing program in the future. This sealing operation is performed by Contractor forces.

The saw-and-seal procedure entails sawing and sealing joints in bituminous overlays shortly after construction. This procedure provides stress-relieving joints at regular spacing over the original concrete joints, thus eliminating uncontrolled reflection cracks from occurring at a later time. This procedure will be used more frequently in future years, and consequently, more joint sealant will be required. Here again, however, in the context of a recycling measure, the usage of rubber would be relatively small. For example, if the use of the saw-and-seal technique were to triple from last year's 500,000 lineal feet, only about 82 tons of sealant (20 tons of rubber) would be used.

### 3.3 LANDSCAPING APPLICATIONS

Scrap auto tires which are processed into a granular form have been used experimentally as a landscaping material in various applications. For example, a study conducted in 1975 by Purdue University and the Indiana State Highway Commission investigated the use of shredded rubber tires as a mulch material. Their conclusions indicated that two inches of shredded rubber was effective for weed control. A study conducted by California DOT suggested that reclaimed rubber might be used as a soil conditioner and stabilizer in harsh environments such as on steep slopes in the desert. There may be potential for the use of scrap rubber in similar landscaping applications, but little effort is being devoted to this area because of the inherent aesthetic problems.

### 3.4 SCRAP TIRES AS A STRUCTURAL MATERIAL

Discarded auto tires, although treadworn, are still a structurally sound material. In underdeveloped countries, they are used for a variety of construction uses such as walls, animal pens, outdoor staircases, etc.

In the United States, the use of discarded auto tires as a structural material in the roadway environment is under study. Texas and Connecticut have designed and tested inertia barriers constructed with discarded automobile tires as the container for the sand mass. These worked satisfactorily, however, no extensive use of their design has been made.

The most interesting use of discarded auto tires as a structural material has been under study by California DOT for the last nine years. Recent legislation requiring new means of disposing of old tires has resulted in the development of tire-anchored timber walls. These retaining walls were constructed with discarded tire sidewalls and railroad ties. The tire sidewalls are hidden in this design, effectively eliminating all of the aesthetic problems. They have performed excellently, withstanding an earthquake which registered 5.8 on the Richter Scale. In addition to outstanding performance, these timber walls were constructed at a savings of \$23/sq. ft. compared to the standard design. New Jersey has yet to try any of these innovative designs using discarded auto tires as a structural material.

### 3.5 SCRAP TIRES AS A FILL MATERIAL

One possible alternate disposal technique for used tires that has yet to be tried is presently under consideration by the Department. This method would involve incorporating scrap tire rubber into fill material to be used in highway embankments. Because of the tendency of tires to float within landfills, the tire rubber would probably need to be cut or shredded. The use of tires in

embankments might be considered when borrow material must be obtained. Further research would be required to determine the potential for scrap tires as fill material on highway embankments.

#### 4.0 DISCUSSION - OTHER APPLICATIONS

Many environmental protection groups and governmental agencies have promoted the use of scrap auto tires for many different applications. Automobile tires have been used extensively in the manufacture of shoes in India, for building construction in Mexico, etc. In the United States, small scale alternatives to disposing of scrap auto tires have been tried such as:

- Artificial reefs
- 2. Tire playgrounds
- 3. Dock and ferryslip bumpers
- 4. Artificial running tracks

More developments in these areas are clearly required. The New Jersey Department of Energy's 1983 Municipal Recycling Tonnage Grant Program takes a first step towards encouraging municipalities to utilize used tires by retreading, recapping, and building artificial reefs. Additional emphasis should be made on encouraging private industry to develop products manufactured from used tires and reclaimed rubber.

#### 5.0 SUMMARY

Although New Jersey has not made any extensive use of discarded automobile tires in highway construction, there exists some potential for their use in rubber-filled bituminous concrete, joint and crack sealers, tire anchored timber walls, and as fill material for embankments. At present, the cost for disposing of one used automobile tire in New Jersey averages \$2.00. This cost

will surely increase in the future as landfill space becomes more and more scarce.

However, there are serious problems to be considered before making a commitment to rubberized roadways, structures, or embankments in New Jersey:

1. Costs of paving mixes modified with scrap rubber from tires are likely to be significantly higher than conventional mixes.
2. There is at least some question as to whether rubberized pavements can be safely recycled.
3. The engineering properties of granulated rubber may vary substantially, depending on the type of tire used.
4. The engineering properties of tire sidewalls may vary substantially, depending on the type of tire used.
5. Laboratory test procedures must be developed which can quantify the properties of rubber-modified mixes and sealants.
6. In order to realize the full benefits of using scrap rubber, local sources must be made available.

These items must be thoroughly investigated before any major commitment is made to use discarded tires/reclaimed rubber in highway construction and maintenance work. It is expected that as the number of available disposal sites decrease and disposal costs increase, more emphasis will be placed on developing alternate uses for all types of waste materials, including used tires. If, in fact, the recently proposed EPA procurement regulations are adopted, which will require that asphalt materials containing ground scrap tire rubber are used when "technically or economically appropriate", it is expected that research in this area will be further stimulated.