USE OF RECYCLED SCRAP TIRE RUBBER
IN THE CARSONITE NOISE BARRIER

by

Anton J. Horner

I. CONCEPT

In a new process, scrap tire waste can be used in combination with a structural element to create an aesthetically pleasing, functional, and long-lasting noise barrier wall. The recycled scrap tire core consists of a mixture of several crumb rubber sizes and/or recycled plastic. A ten-foot-high, one-mile-long wall will consume 250,000 lbs. of scrap tire rubber. Scrap rubber would come from breakdown plants already in operation. Such plants already exist and there is no need nor would it be economical to construct additional plants for a specific product. The existing breakdown plants can supply the needed scrap rubber in any form desired. What is needed are additional markets for the scrap tire. As market use increases, scrap tires will be drawn not only from present tire recyclers but also from waste heaps. An important advantage of using scrap tires for the core of the noise wall is that age or chemical changes from exposure of the tires to the elements will not limit its use, which may not be true for molded products or rubber added as an additive to asphalt.

The structural element, shaped into a tongue-and-groove building plank, is a fiberglass-reinforced polymer composite with strict material requirements that has consistent and predictable mechanical properties with an expected life cycle of 50 years. The glass-reinforced polymer contains flame retardants, is self-extinguishing, and is protected by ultraviolet inhibitors to prevent solar degradation. The tongue-and-groove structural element is manufactured by a continuous process that ensures high quality and structural soundness to meet the load-bearing requirements of the sound wall. Waste materials are not used in its manufacture.

Carsonite has used this process in developing and manufacturing over 100 million linear feet of similar reinforced composite products. These products are used by many agencies, including highway departments, public works departments, utility companies, major pipeline companies, the U.S. Forest Service, and the Bureau of Land Management.

The Carsonite wall will be erected using a simple post and foundation design. Concrete or steel posts can be used with slotted design that allows insertion of the prefabricated panels with light weight lifting equipment. A wall panel 10-foot by 10-foot will weigh only about 800 pounds. Similarly, the wall can be removed, reassembled in a new location without large construction equipment. The wall can be manufactured in virtually any color or with variable shading.

II. AVAILABILITY OF WASTE TIRES

Studies indicate that about one scrap tire is generated annually for every U.S. citizen. As a result, about 285 million tires need to be disposed of every year. Discarded tires are a major contributor to the waste stream and create a problem of appropriate disposal procedures because of their bulk and enormous quantities generated annually. To reduce their bulk, tires are ground or chipped before they are landfilled. This grinding process is a large waste of energy because this material is not productively used.

Of the 285 million tires discarded every year, about 33 million tires are retreaded and 22 million tires are reused or resold. Another 42 million are diverted to various other uses. The remaining 188 million tires are added to stock piles, landfills, or illegal dumps across the country. The U.S. Environmental Protection Agency in 1991 estimated that the present size of the scrap tire problem is 2 to 3 billion tires. (EPA 1991)

Most of the markets using the 97 million recycled tires cannot support additional expansion. The supply of retread, reused, and processed rubber products meets or exceeds the existing demand. These saturated markets represent 70% of the present demand for scrap tires.

1Carsonite International Corporation, Corporate Headquarters, 1301 Hot Springs Road, Carson City, Nevada 89706-0601

5-69
CARSONITE SOUND BARRIER PLANK

Figure 1 depicts the structural shape and dimensions of the structural plank.

SECTION OF ASSEMBLED WALL WITH 3 STRUCTURAL PLANKS

Figure 2 depicts the configuration of a section of an assembled wall using the structural plank with its recycled rubber core.
Of the available expanding markets for scrap tires, only two have shown potential to use a significant number of scrap tires: fuel for combustion and crumb rubber modifier for asphalt paving. Combustion already plays a major role, consuming 26 million tires annually. Crumb rubber modifier, which currently consumes 1 to 2 million tires per year, can incorporate the rubber from 2 to 6 tires into a metric ton of hot mix asphalt paving material. To recycle 10 million scrap tires annually as crumb rubber modifier, 2 to 5 million metric tons of hot mix asphalt material would need to be modified (Federal Highway Administration 1992).

As a result of congressional concern about the scrap tire problem, Section 1038 of the Intermodal Surface Transportation Efficiency Act of 1991 was passed in 1992. Section 1038 of this Act requires that all states use crumb rubber modifier in constructing asphalt pavements. This section mandates that all states increase their use of crumb rubber modifier in asphalt pavements as a percentage of the total tons of asphalt laid from 5% in 1994 to 20% in 1997 and each year thereafter. The use of crumb rubber modifier in asphalt pavements is still experimental in many states. Crumb rubber modified asphalt is expensive, and a corresponding enhancement in asphalt pavement performance has not been proven. Congress recognized these concerns and required the Federal Highway Administration and EPA to study the environmental effect, performance, and other aspects of combining crumb rubber modifier with asphalt pavements (U.S. Congress 1991).

Alternative highway uses exist for scrap tires. The Transportation Research Board (TRB) initiated a study in 1989 to document these alternative uses. Several highway agencies have examined the potential use of scrap tires or rubber processed from scrap tires for lightweight embankments, retaining walls, safety hardware, and pavement sub-base. Details of these uses will be published in a TRB synthesis in the future (Federal Highway Administration 1992).

State and national legislation has been initiated as a result of environmental risks linked to the presence of scrap tire stock piles and a number of recent, well-publicized tire stockpile fires. By the beginning of 1991, 44 states had drafted, introduced, regulated, or enacted laws to control the scrap tire problem. Typical provisions of the states legislation include regulations to control the processing, hauling, and storage of scrap tires; restrictions on scrap tires and landfills; provisions for funding, normally a tire disposal fee; and in a number of states, incentives for developing new alternative use markets (Federal Highway Administration 1992).

A number of states are concerned that they will become importers of scrap tires if regulations and controls are not established. They also realize that markets must be developed locally for recycling scrap tires because tires cannot be disposed of in landfills or exported to other states. It is evident that new products and new technology for the use of scrap tires must be developed.

III. PROCESSING OF WASTE MATERIAL

In view of the concerns by government agencies and the public about the waste tire problem, breakdown plants for scrap tires are being constructed in major urban areas. This is due to the need for scrap crumb rubber for products or simply to provide a mechanism to cut up or chip scrap tires for burning or disposal in landfills. As a result, various sizes of scrap rubber can be obtained at a reasonable cost. Uses for by-products of the breakdown process are needed to avoid burning which is not considered desirable in many areas or disposition in landfills which is an unnecessary loss of a natural resource.

The Carsonite noise barrier design allows the use of various sizes of recycled rubber in wall core. Waste buffings from recap operations can also be used in combination with various sizes of crumb rubber. Scrap rubber is therefore available for this use without creating additional cost to the recycling industry.

The scrap tire rubber used for the core could include steel and/or fibers. However, breakdown plants normally separate the scrap tire into its components making scrap rubber available in uniform sizes for easy handling and production of the rubber core.

The manufacture of the recycled scrap core can be accomplished by a simple, cold and environmentally safe cold mixing and filling process, or it can be done by the use of a well developed extrusion process wherein recycled plastic is incorporated. These methods require little energy and will not have negative environmental results.

The recycled rubber core is placed in the structural shell by mechanical means. Several sizes of scrap rubber can be used but a single size will accomplish the desired result. Scrap rubber sizes have been used from 1/4" to very fine material. Experimentation with the filling process has been successful using gravity, vacuum and augering devices. Mixing of several sizes can be accomplished with commercially available continuous or batch type mixers.

Constructing the noise barrier will use a waste material, recycled rubber, in a productive and cost effective man-
This will reduce the waste stream problem, without requiring new processing methods for scrap tires.

IV. TEST RESULTS

A first-generation prototype of the noise barrier wall has been constructed at the manufacturing plant, showing that the wall is feasible and effective as a noise barrier. The design is being refined and includes new architectural treatments and revised structural details. A second-generation prototype will be built in the near future.

The following tests have been performed that reflect the barrier's effectiveness and acceptability under environmental requirements:

- **Noise Attenuation**—A minimum sound transmission class of 25 is required, whereas the Carsonite sound barrier wall has a sound transmission class of 36. The sound barrier has a noise reduction coefficient (measure of sound absorption) of 0.15, compared with 0.01 and 0.10 for concrete and wood, respectively.

- **Flame Spread**—ASTM E84 test results: Flame spread - 20, smoke density -275. Based on these test results, the barrier is classified as a Class I Building Material suitable for indoor construction.

- **Toxic Characteristic Leach Procedure (TCLP)** This procedure is approved by the federal EPA for acceptance of material as nontoxic for disposal, handling or contact with the environment.
  - **TCLP metals**: All components of the wall meet regulatory requirements for presence of arsenic, barium, cadmium, chromium, lead, mercury, silver and selenium.
  - **TCLP volatiles**: All components of the wall meet regulation requirements for benzene, carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethylene, tetrachloroethene, trichloroethylene, vinyl chloride, and methyl ethyl ketone.
  - **TCLP semi-volatiles**: All components of the wall meet regulation requirements for presence of O-cresol, M-cresol, P-cresol, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenzene, nitrobenzene, pentachlorophenol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, hexachlorobutadiene, hexachloroethane, and pyridine.

- **Reactivity, Corrosivity, and Ignitability**—The wall components meet regulatory requirements.

All of these tests indicate that the components of the Carsonite sound barrier wall meet regulatory requirements relative to EPA toxic material specifications, safety, and FHWA sound barrier criteria for effective noise blocking.

V. PERFORMANCE DATA

The structural element shaped into a tongue-and-groove building plank is a glass fiber reinforced polymer composite. The composite has consistent and predictable mechanical properties with an expected life cycle of 50 years. The tensile and compressive strength of the composite is over 60,000 psi. The glass reinforced polymer contains flame retardant, is self extinguishing, and is protected by UV inhibitors to prevent solar degradation. Any color can be compounded with the manufacturing process, providing a wide selection of treatments that won’t fade or peel. This structural element is manufactured in a continuous process ensuring high quality and structural soundness. Since the composite is manufactured with a high glass fiber content and bonded with inert polymer, the structural element will not peel, rot or be subject to deterioration from chemicals or salts.

Glass fiber reinforced polymer composites have been used in many construction elements for over 40 years. Well known uses include boats, aircraft, buildings, electrical, mass transit vehicles and chemical plants. These types of applications are often exposed to the most demanding chemical, flame retardant, electrical and environmental requirements.

The recycled rubber core is completely encapsulated by the fiberglass reinforced composite and is therefore protected from the environment, fire, water and roadside chemicals and salts.

The fiberglass composite is expected to have a 50 year life based on previous experience and various laboratory exposure tests performed on the manufactured structural element. Tests for Xenon-arc weatherometer periods of 2000 hours (representing 20 years of outdoor exposure) show that strength is not appreciably diminished nor is there unsatisfactory visual degradation. Reduction in stiffness and tensile strength were limited to a reduction of 4.4% and 16.5% respectively. These results are well within acceptable limits for satisfactory performance of the barrier over the long term. The samples exhibited negligible fading or cracking after 2000 hours of weatherometer exposure.
VII. MANUFACTURING PROCESS

Composites were developed for aerospace use many years ago. The composites are manufactured by drawing continuous fiber mat and roving reinforcements through a resin bath to coat each fiber with a specially formulated resin mixture. The coated fibers are assembled by a forming guide and then drawn through a heated die.

Cure of thermosetting resin is initiated by heat in the die and catalyst in the resin mix. The rate of reaction is regulated by controlled heat in the die.

The resulting high strength profile is cut to length and is ready for use as it leaves the pultrusion machine.

The manufacturing process for the rubber core is described in Section III.

VIII. BENEFITS & COSTS

a. Benefits of the concept are as follows:

- The scrap tire waste stream will be reduced substantially, whenever this noise barrier concept is constructed.

- A reduction in total overall energy use will result. Tires now placed in landfills must often be chipped or cut up with no productive use of the rubber scrap. Also, when placed in dumps, this resource is lost forever. Using the scrap rubber will replace other natural materials and their production, such as steel, brick or wood. These are traditional materials used in noise wall construction and have high energy production costs.

- The scrap rubber will replace natural raw materials that are often non-renewable.

b. Market & costs:

The last summary report by FHWA indicates that about 720 miles of noise walls were constructed in the United States by 1989. Substantial increase in noise wall construction has occurred since then due to public awareness and demand (Federal Highway Administration 1991). California alone is expecting to construct noise walls that will cost $350 million over the next seven years. A reasonable projection for noise wall for the nation would be $1 billion for the same time period. Equating $1 billion construction costs to miles of wall would equal about 1,000 miles of new barrier construction. This is a significant market which has large potential for using substantial scrap rubber.

Scrap tire rubber is available in every state and is a major problem in the waste stream; providing the incentive for states to take advantage of a new product and at the same time solve a local environmental issue. The scrap tire filler for the core can be manufactured locally anywhere in the country as a simple cold process that is environmentally sound.

The Carsonite sound barrier wall can be constructed, including posts and foundations, for an estimated $15 to $17/ft². In 1989, the national average cost for construction of noise barrier walls was $15/ft²; this cost included all kinds of walls, such as earth mounds, which are relatively inexpensive. Considering adjustment for inflation, the Carsonite sound barrier wall can compete with other walls of similar construction and projected life. As production of the Carsonite barrier increases, the cost will be reduced and be very competitive with walls constructed from other materials such as concrete and steel.

c. Other potential uses

Concepts are being investigated for using the Carsonite barrier in low retaining wall applications. A proposal for erection of the barrier on structures as splash guards during snow plowing operations is under consideration and entering the design phase in one state. Its light weight and resistance to corrosion from chemicals and roadway salts make it especially adaptable to uses in northern and marine climates.

REFERENCES


Intermodal Surface Transportation Efficiency Act of 1991, Section 1038.
