Asphalt Shingle Recycling

Executive Summary

The Georgia General Assembly passed legislation in 1997 requiring asphalt roofing shingles to be disposed of either in construction and demolition or municipal solid waste landfills and encouraging the recycling of asphalt shingles. The legislation also required the Pollution Prevention Assistance Division to work with the Environmental Protection Division to develop a plan to encourage asphalt shingle scrap recycling. This report has been prepared in response to this legislative requirement.

This report provides information on generation, characteristics and opportunities to recycle asphalt shingles in Georgia. The information is intended to help manufacturers of asphalt shingles find alternatives to landfilling, to inform road contractors about opportunities to recycle asphalt shingles in road pavement, and to encourage generators of asphalt roofing to recycle this material for use in roads, thereby reducing the amount of waste going into landfills in the state. Information in the report was gathered from several sources including a literature search and personal communications.

The asphalt shingle is the most common type of roofing material used in both new home construction and reroofing, accounting for over 60% of the residential roofing market. Asphalt shingle scrap is generally recyclable because: 1. it is generated separately or can be segregated from other components of the solid waste stream; 2. the technology exists for processing asphalt shingle scrap to meet the requirements for use as a raw material; and 3. the processed scrap is a valuable alternative raw material in the production of hot mix asphalt.

The benefits of recycling asphalt shingle scrap include:

- Reduction in solid waste quantities and conservation of landfill space.
- Potentially lower disposal costs for asphalt shingle scrap generators.
- Reduced production cost of hot mix asphalt (HMA).
- Possible improved resistance to pavement cracking and rutting due to the reinforcement provided by fibers contained in shingles.
- Conservation of virgin material.

It is estimated that 216,000 - 330,000 tons of asphalt shingle scrap are generated in Georgia, which could be used to produce 4.1 to 6.3 million tons of HMA. According to the Georgia Department of Transportation (Georgia DOT), 15 million tons of asphalt are produced in the state each year for public and private paving. Therefore, in theory, it is possible to incorporate all the asphalt shingle scrap generated in the state into HMA.

The cost savings resulting from incorporating asphalt shingle scrap into HMA, a mixture of asphalt and aggregate of various sizes used for road pavement, depends upon several factors. According to the National Asphalt Pavement Association (NAPA), these factors include: the savings from raw materials (i.e. asphalt cement and fine aggregate) and reduced disposal fees. However, the cost of transportation associated with receiving the shingles and the cost of preparing the shingles for use in the mix must be considered to determine the net savings of using asphalt shingle scrap in the HMA. According to asphalt shingle manufacturers in the state and a contractor who owns and operates hot asphalt mixing plants in Georgia, tipping fees in the range of $20 - $30 per ton make recycling asphalt shingles into road pavement economically viable. According to NAPA, cost savings associated with the use of 5% asphalt shingle scrap in HMA have been estimated to be between

$1.00/ton to $2.80/ton.

To encourage the use of asphalt shingle scrap in pavement, the Georgia DOT has modified the specifications for hot mix recycled asphalt concrete to allow both manufacturing shingle scrap and reroofing shingle scrap. These materials are limited to 5% of the total mixture and will be handled and stockpiled in the same manner as conventional recycled pavement materials. Shingle mixes are also expected to conform to the same quality standards of conventional mixes. Georgia is one of nine states to have such specifications. The state also requires the shingle scrap to be shredded to less than ½ inch and an asbestos test to be administered for every 1,000 tons.

To fully utilize asphalt shingle scrap generated throughout the state for HMA, several actions may be required:

- sufficient capacity must be available to shred asphalt shingle scrap (while there is one such facility in existence in the state, this may require the addition of other shredding facilities).
- scrap must be transported to the shredding facility(ies), which may require the development of collection locations in those parts of the state which do not have ready access to a shredding facility in order to encourage generators to recover and deposit shingle scrap.
- shredded scrap must be transported from the shredding facility(ies) to the hot mix asphalt plants, which may require the development of a transport system for this purpose.

To determine the economic feasibility of recycling asphalt shingle scrap, taking into consideration the current and projected costs of disposal in Georgia and the costs associated with processing and transporting the scrap, it is recommended that a demonstration project be undertaken by the Environmental Protection Division, utilizing funds available from the solid waste trust fund.

To encourage the recycling of asphalt shingle scrap, education of the major stakeholders is needed to promote the opportunities for asphalt shingle recycling in Georgia. Once the demonstration project is completed, educational materials could be prepared documenting the results of the demonstration project. In addition, a technical assistance program could be developed and targeted toward building contractors, hot mix asphalt plant managers, construction engineers, road contractors, manufacturers of asphalt shingles, and state and local government officials. The
objective of the technical assistance program would be to communicate the environmental and economic benefits of recovering asphalt shingle scrap for use in road pavement.

If a state technical assistance program is developed, it would be beneficial for the program to be incorporated as a part of the Pollution Prevention Assistance Division's solid waste reduction technical assistance program in partnership with the Environmental Protection Division and the Georgia DOT.

1.0 Background

A typical asphalt shingle is essentially an organic or fiberglass mat saturated with asphalt and covered by a surface of mineral granules. The composition of scrap shingles may vary depending upon the manufacturer. Newer shingles typically are made with a fiberglass mat, while older shingles were likely to be made with an organic material.

NAPA estimates waste asphalt shingles typically contain the following:

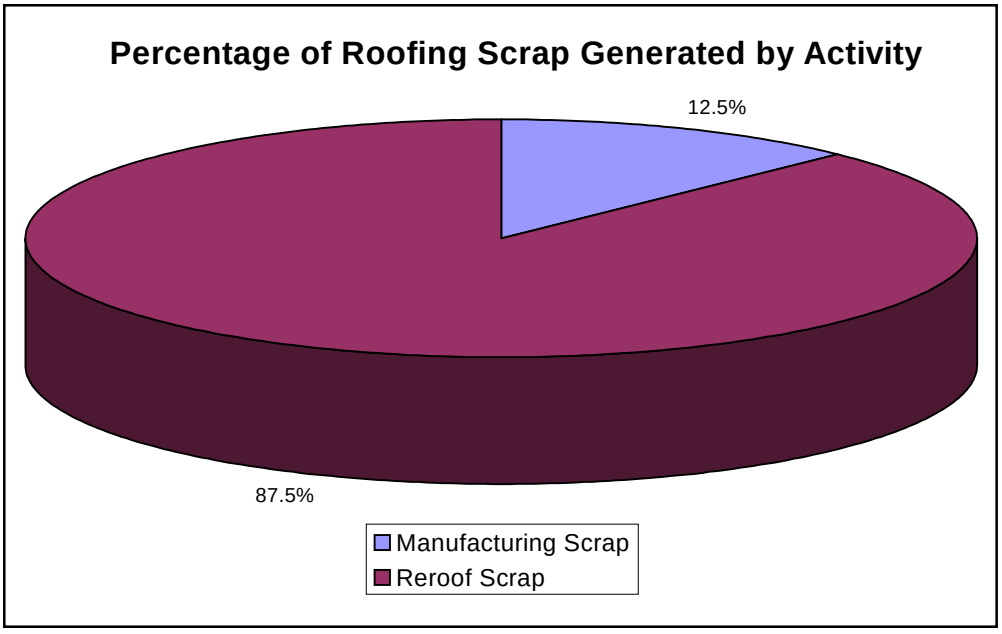
- 30% to 40% asphalt cement which is considerably harder (about 25 penetration) than paving asphalt;
- 40% to 60% hard rock granules (minus No. 10 sieve) and mineral fillers (minus 0.15 mm); and
- 1% to 12% fiber (0.5- to 4.5-mm long fiberglass or cellulose), felt, and miscellaneous materials.

The asphalt shingle is the most common type of roofing material used in both new home construction and reroofing, accounting for over 60% of the residential roofing market. NAPA reports that 10 million tons of asphalt shingles are manufactured each year in the United States, and approximately two-thirds of the shingles manufactured are used for reroofing houses and one-third are used on new houses. There are 77 factories in the United States - five of which are located in Georgia - that manufacture asphalt shingles. Three of the factories in Georgia are located in the Atlanta metropolitan area and two are in the Savannah area.

According to Dr. Brock of Astec Industries in Chattanooga, Tennessee, the manufacturing of asphalt shingles generates scrap materials that typically range from 5 to 10% of total production. Asphalt shingle roofs generally last from 12 to 20 years before requiring replacement or recovering. Factors that affect how often shingles should be replaced include the type of shingle and weather conditions.

2.0 Generation

Scrap asphalt shingles are generated during the manufacturing of asphalt shingles and roofing and reroofing activity (reroofing scrap or tear-offs). Based on information provided by 4 of the 5 manufacturing facilities in Georgia, more than 450,000 tons of asphalt shingles are manufactured in the state. Manufacturing scrap comes from trimmings and "out-of-spec" shingles from the production process. Manufacturers have indicated that, because of the speed at which the shingle manufacturing line typically moves, historically it has been cheaper to pull and scrap suspect shingles from the line than to slow down production to reduce the amount of "out-of-spec" shingles that are produced.



Reroofing scrap is defined as old shingles torn off roofs when replacement is necessary. It sometimes contains more than 30% asphalt by weight, since some of the aggregate in scrap shingles has been lost due to weathering during service. The aged binder is hard and sometimes even embrittled, and therefore, lends itself to shredding more easily for recycling in road surfaces. In addition, reroof scrap may contain contaminants (e.g, nails, wood, paper,

plastic films, asbestos and miscellaneous trash).

The actual quantity of asphalt shingle scrap generated in Georgia is not known, nor is it possible with current management practices to develop a method for quantifying this material. However, for the purpose of this report, an attempt has been made to estimate quantities based on information available from NAPA, National Association of Home Builders (NAHB) and other sources. These sources have been used to calculate the following estimates.

- NAHB estimates that asphalt shingles comprise 10% of the construction and demolition (C&D) waste stream. Based on information reviewed by the Pollution Prevention Assistance Division (P^2AD), in 1996 approximately 3,297,000 tons of C&D waste were disposed of in Georgia. 1,753,000 of which was disposed in C&D landfills and 1,544,000 in municipal solid waste landfills. If it is assumed that 10% of this waste stream was asphalt shingles, approximately 330,000 tons of asphalt shingle scrap were disposed in Georgia in 1996.

- Using NAPA's estimate that 10,000,000 tons of asphalt shingles are manufactured annually in the United States, Dr. Brock of Astec Industries, a national producer of asphalt paving products, plants and machinery, estimates that consumer demand (assuming that nationally the quantity manufactured equals consumer demand) for asphalt shingles is equal to 75 pounds of asphalt shingles per person per year. Based on this estimate, approximately 277,000 tons per year of asphalt shingles are manufactured for use in Georgia. The NAPA estimates that two-thirds of these shingles will be used for reroofing with a one to one ratio existing between the amount of shingles used for reroofing and the amount of asphalt shingle scrap being generated. Applying these estimates, approximately 184,092 tons of asphalt shingle scrap are generated annually from reroofing activities in Georgia.

- Based on information provided by the five manufacturers in Georgia, approximately 29,540 tons of scrap were generated per year during the manufacturing process. This estimate does not include the manufactured scrap that is known to have been diverted from disposal for beneficial use, such as in pavement.

- Based on information from the U.S. Census Bureau and F.W. Dodge it is estimated that approximately 63,882 new homes, with an average square footage of 2,051, were constructed in Georgia in 1996. NAHB estimates that approximately 8,000 pounds of construction waste are generated per 2,000 square foot home of which approximately 1% is asphalt shingle scrap. Using these statistics, it is estimated approximately 2,555 tons (or 80 pounds per home) of asphalt shingle waste is generated from new home construction in the state.

- In total, the estimated quantity of asphalt shingle scrap generated from new construction (2,555 tons), reroofing activities (184,092 tons) and the manufacturing of asphalt shingles in Georgia (29,540) result in a total of approximately 216,187 tons of scrap being generated annually in the state.

As a result of the above calculations, it is estimated that between 216,000 and 330,000 tons of asphalt shingle scrap are generated in Georgia per year with 29,540 of this total (9% - 14%) being generated by the manufacturers of asphalt shingles located in the state.

3.0 Alternatives to Disposal

Historically, asphalt roofing scrap has been disposed in landfills. As long as landfill tipping fees were low, there was no incentive to develop alternative management technologies for this waste stream. However, as landfill availability decreases and tipping fees increase, interest in finding alternative ways to dispose of asphalt shingle scrap increases. In addition, as liquid asphalt prices surpass $150 per ton, use of asphalt shingle scrap as an alternative raw material becomes more economically attractive.

The U.S. Department of Energy's (DOE) Energy Conservation Branch issued a 1984 report, Recovery and Reuse of Asphalt Roofing Waste, which explored a number of options for reuse and recycling of asphalt roofing shingles including burning for fuel, incorporating shingles into asphalt paving, converting the shingle asphalt to No. 6 oil, recovering the shingle asphalt by solvent extraction, recycling roofing scrap as filler, and converting roofing scrap into new products. The report stated that the two most viable uses of shingle scrap were incorporation into asphalt road pavement and use as fuel in waste to energy plants. Additional research has been done in several of the other areas, but according to DOE contractor Phil Shepard, the other alternatives have not been found to be economically beneficial. In addition, NAHB reports that some attempts have been made to recycle asphalt shingles into new shingles, but problems persist in processing shingles to conform to feedstock requirements.

3.1 Using Asphalt Roofing Shingles as an Energy Source

Asphalt has an energy value of 17,000 Btu per pound. As a result, asphalt contained in reroofing scrap generated in the U.S. represents an energy resource of more than 7×10^{13} Btu/year. This is equivalent to the energy generated from 3 million tons of coal. Some of the factors that need to be taken into consideration when evaluating the feasibility of burning asphalt shingle scrap include:

- Use as a fuel requires a steady supply of material.
- Equipment must be available to shred the material and separate contaminants and feed the shredded scrap into the combustion system.
- The Btu value of shingle scrap varies depending upon the type of shingle (i.e., fiberglass shingles have less asphalt than organic felt shingles) and the quantity and characteristic of contaminants present in the scrap.
- The potential that the total Btu value available from waste shingle scrap may decline as fiberglass shingles replace organic shingles, and shingles are manufactured to last longer.

One concern with using reroof scrap as a fuel source is the presence of contaminants, such as asbestos. Combustion at temperatures below 1800°F may free the asbestos from its bound state. In its free state, asbestos is considered a hazardous material. At temperatures higher than 1800°F, asbestos is broken down and converted to a mineral that is not considered a hazardous material by EPA.

3.2 Using Asphalt Roofing Shingles in Road Construction

Asphalt shingle scrap lends itself to recycling into road construction products because:

- it can be separated from other waste streams;
- the technologies exist for recycling it into pavement; and

- the concentration of asphalt (approximately 19% - 36%) in asphalt-based roofing materials is higher than the asphalt concentration (approximately 5%-6%) in conventional road surface materials.

Asphalt shingles also contain sand and mineral filler comparable to the filler material used in asphalt pavement. When asphalt shingles are used, the quantity of fillers that must be purchased is reduced with an accompanying reduction in cost.

Many states, including Georgia, have conducted field tests on asphalt shingle recycling or have incorporated asphalt scrap shingles into asphalt roads on at least a limited basis. A number of state Departments of Transportation have determined that the integrity of the road surface has not been impaired when scrap shingles are incorporated into the HMA. In fact, the integrity of the road surface may be enhanced by the addition of asphalt shingles. This is due to fibers contained in the shingles which act as a reinforcement in the pavement and aid in improving resistance to rutting.

The biggest hurdles for recycling asphalt shingles into pavement involve removing contaminants (particularly from reroofing scrap) and grinding it to the proper size. However, the technology exists for both and has been tested successfully in Georgia.

Manufacturing asphalt shingle scrap is preferred for asphalt paving mixtures, because it is uniform in composition, derived from one source, normally free of contaminants, and preprocessing involves shredding only. In comparison, reroofing scrap may come from many sources, have varied compositions and may contain an assortment of contaminants including asbestos. Although asbestos was eliminated from shingles manufactured after 1973, there are intermittent instances of asbestos-containing shingles in the waste stream primarily as a result of scrap generated from reroofing of older homes and buildings. A study conducted by the Texas Transportation Institute estimated that approximately 1 in 200 roofs have asbestos in the shingles. U.S. EPA does not classify asphalt roofing containing less than 1% asbestos as hazardous waste (40 CFR 61.141).

The waste shingles may also contain sulfur and coal tar. The sulfur may release SO_2 emissions, if burned. However, the other particles may bind with the sulfur, eliminating the SO_2 emissions. The presence of coal tar could be a significant impediment as coal tar is not compatible with asphalt.

To be used in road construction, the shingle scrap must be shredded. While shredding equipment costs in excess of one million dollars, one machine can serve a large area and provide feedstock for many HMA facilities. One potential problem involved with the shredding operation involves stockpiling the asphalt shingles. In the summer heat, ground scrap may "melt" together in one mass if sand or some other fine aggregate is not mixed throughout the pile. Providing cover for the shingles to protect them from direct sunlight may also be necessary to prevent the scrap shingles from "melting".

The cost savings resulting from incorporating asphalt shingles into HMA, a mixture of asphalt and aggregate of various sizes used for road pavement, depends upon several factors. According to NAPA, these factors include: the savings from raw materials (i.e., asphalt cement and fine aggregate) and reduced tipping fees. However, the cost of transportation associated with receiving the shingles and the cost of equipment for preparing the shingles for the mix must be considered to determine the net savings of using asphalt shingles in the HMA. According to asphalt shingle manufacturers in the state and a contractor who owns and operates hot asphalt mixing plants in Georgia, tipping fees in the range of $20 - $30 per ton make recycling asphalt shingles into road pavement economically viable. According to NAPA, cost savings associated with the use of

5% waste asphalt shingles in HMA have been estimated to be between $1.00/ton to $2.80/ton.

The NAHB has identified the following uses for scrap asphalt shingles in the pavement structure:

- Aggregate base course
- Granular base stabilization layer
- Parking lots or temporary roadways
- Pothole/road patch material
- Hot mix asphalt

Aggregate Base Course

A typical roadway section is built in several layers. The base, which supports the pavement, is made of a layer of aggregate. The pavement, or surface layer, is made of concrete or asphalt. Asphalt-based roofing scrap can be reduced to small pieces (approximately 2 1/2 inches or smaller) and used as an alternative to stone and gravel. This low-end asphalt paving mixture, which incorporates high percentages of asphalt roofing, may be able to successfully compete with rock and gravel as a ground cover alternative. This mixture could also be used as a dust suppressant on projects such as rural roadways or temporary construction surfaces.

Granular base stabilization layer

Ground asphalt shingles can also be used for stabilization of wet and muddy areas. Typically, asphalt shingles are ground and mixed with significant quantities of crushed asphalt pavement for use as a ground cover in these applications.

Parking lots or limited access roadways

Parking lots or limited access roadways can be constructed by spreading asphalt shingle scrap ground to 3 inches or less over an area. I.C. Solutions in California has developed a method of applying the ground scrap at a rate of 644 tons per acre, which yields a cover approximately 5 inches thick. The process uses a vibrating compactor of 8 to 10 tons to pass over the surface. The heat from the sun and heavy vehicle traffic then helps to "melt" the shingles into one mass. This type of surface suppresses dust and can be used for equipment yards and parking areas.

The Greater Lebanon Refuse Authority in Pennsylvania has patented a process to use ground reroofing scrap as an alternative to gravel for roadways by mixing the scrap with crushed stone and spreading it between two layers of stone. The benefits include the ability to absorb oil that drips from automobiles and its porosity, which permits water (rain) to run through it. The road base has been used satisfactorily on Lebanon County landfill roads for two years.

Pot hole/road patch material

Shredded roofing shingles are also being used to make cold patching materials or paving materials (e.g., bike paths and park trails) containing up to 100% shingles. This type of product has the potential to utilize higher percentages of reclaimed roofing and could offer a price advantage because of a lower weight to volume ratio than traditional products.

Typically, the consumer scrap is ground to less than ½ inch and blended with aggregate to produce patching mixes to fill potholes. Heating during mixing and/or addition of solvents such as diesel, kerosene, or asphalt rejuvenating (or recycling) agents may be required to activate the air-blown and possibly aged asphalt in the roofing.

This cold patch product, unlike hot melted tar or asphalt, can be used to fill potholes and patch roadways without the handling and processing problems associated with hot patch products. Application of a cold patch product requires filling a crack or pothole with the material and tamping it down with a shovel or by driving over it. With this method, vehicle traffic can be allowed over the patched area almost immediately after application.

The use of cold patch mixture on expansion joints involves thinning the mixture by putting in less aggregate and more roofing material. This procedure is not currently being used by state DOTs.

Hot Mix Asphalt

Roofing scrap can be incorporated into hot mix asphalt (HMA) for road pavement in much the same way as reclaimed asphalt pavement (RAP). The Georgia Department of Transportation (Georgia DOT) estimates that it has used RAP in approximately 20% of state roadways constructed since 1990. The equipment used in this process can reportedly also accept ground asphalt shingle scrap.

The National Asphalt Pavement Association, reports that scrap shingles can be added to hot mix asphalt in an effective and economical manner. The percentage of scrap asphalt shingles that can be added depends on such local conditions as availability of scrap shingles, the form of the shingles, the type of HMA, whether it is being used in surface or base layers, and the equipment available to process and add the scrap asphalt shingles at the HMA facility. It has been documented that the addition of 5% scrap shingles to HMA is easily accomplished (NAPA). Most highway agencies agree that acceptable paving mixtures containing up to 10% by weight roofing scrap can be produced and that a softer than usual binder should be used to offset the hard binder in the roofing shingles.

Processing manufacturing scrap for this application involves shredding the material down to less than 1/2 inch, while processing asphalt roofing scrap generally requires removing nails and other contaminants before shredding. Astec Industries in Tennessee and GoRoof, Inc. in Florida have developed machinery to shred asphalt shingles to less than 1/2 inch. The material is then fed into the asphalt plant and mixed with virgin asphalt and aggregate to make asphalt concrete (AC). This mixture can be used for resurfacing roads or constructing new ones.

The aggregate used in HMA material is a combination of coarse and fine particles with a small amount of mineral filler added on occasion. The asphalt binder, which consists of the bituminous substance used to bind the aggregate, comprises 5% to 7% of the asphalt concrete. Because the aggregate used in roofing shingles is usually a blend of sand, limestone filler, and synthetic colored granules, the gradation is generally very fine. As a result, when incorporating asphalt shingle scrap into HMA, some or all of the fine aggregate normally added to the mix may be reduced or omitted altogether.

In many cases, the use of shingles improved the stability of the mix. There are several reasons. First, the vast majority of the fine aggregate incorporated into the shingles is very angular and freshly crushed material giving it desirable characteristics for rutting resistance. Further, the addition of the small amount of fibers in the

shingle scrap can also improve the properties of the HMA by reinforcing the thin film of asphalt surrounding the aggregate particles. The effects of both the addition of fine aggregate and fibers can reduce pavement cracking and rutting.

Laboratory and/or field tests have been conducted on asphalt paving mixtures containing reroofing scrap in Florida, Minnesota, Nevada, Massachusetts, Missouri, New Jersey, New York, Pennsylvania, Maryland, Indiana, Tennessee, and Ontario, Canada. Laboratory testing in Minnesota was done on both organic and fiberglass asphalt shingles used as additives for HMA at levels of 0%, 5.0%, and 7.5% by weight of aggregate. Overall conclusions included the following. The mixtures containing scrap shingles exhibited less sensitivity to temperature changes. Tensile strength at 77°F was maintained or increased with the addition of 5% felt shingles, and was decreased when this amount was increased to 7.5%. Fiberglass shingles tended to decrease tensile strength at either the 5% or 7.5% concentration level. At 0°F, the tensile strength of the scrap modified mixtures decreased as the percentage of scrap increased.

Most state DOTs feel comfortable using manufacturing scrap because of its uniform quality, but do not feel as comfortable using reroofing scrap because of its inherent variability and proportion of deleterious materials. One contractor in Florida has been producing ground manufacturing asphalt scrap and using it in HMA for about eight years. Most of the product is applied to city streets and county roads. Florida DOT found increased Marshall stability, tensile strength, and resistance to rutting when manufacturing scrap was included in asphalt concrete.

Tennessee DOT conducted a study on the effects of recycled reroofing scrap in hot mix asphalt. They deleted 5% sand and 5% screenings from a dense-graded mixture in common use and replaced it with 10% recycled roofing. Since the roofing contained 28% asphalt, the virgin asphalt content was reduced slightly. Because the asphalt in the reroofing scrap is quite hard, the asphalt plant mixing temperature was raised by 6 degrees Celsius. Laboratory data suggested the mix was “very satisfactory.”

According to NAPA, higher percentages of asphalt shingle scrap can be used in the base layer as compared to the surface layer. However, there are additional alternatives for using asphalt shingle scrap in pavement, including the current practice of spreading manufacturing shingle tabs (trimmings generated during the cutting process of shingle manufacturing) in driveways and compacting them.

4.0 Opportunities for Recycling Asphalt Shingles in Georgia

It is estimated (refer to Section 2.0) that 216,000 - 330,000 tons of asphalt shingle scrap is generated annually in Georgia. This quantity can theoretically be used to produce 4.1 to 6.3 million tons of hot mix asphalt. According to the Georgia DOT, 15 million tons of asphalt are produced in the state each year for public and private paving. Therefore, in theory, it is possible to incorporate all the asphalt shingle scrap generated in the state into HMA. There are 130 HMA plants located throughout the state that can accept shredded, asphalt shingle scrap for use in road pavement.

To encourage the use of asphalt shingle scrap in pavement, Georgia DOT has modified the specifications for hot mix recycled asphalt concrete to allow both manufacturing shingle scrap and reroofing shingle scrap. These materials are limited to 5% of the total mixture and will be handled and stockpiled in the same manner as conventional recycled pavement materials. Shingle mixes are also expected to conform to the same quality standards of conventional mixes. Georgia is one of nine states to have such specifications. The state also

requires the shingle scrap to be shredded to less than ½ inch and an asbestos test to be administered for every 1,000 tons.

Georgia DOT began looking at the use of recycled shingle materials approximately seven years ago. The following paragraphs provide a summary of their investigation and results.

In 1993, GAF Building Materials, Inc., an asphalt shingle manufacturer located in Savannah suggested the use of their scrap for road pavement. The company was spending approximately $96,000 for disposing of 5,800 tons of scrap shingles. The Georgia Department of Transportation evaluated the feasibility of using GAF's scrap shingles in HMA mixtures. APAC Georgia, Inc. tested the recycled shingle scrap in trial mixes placed in parking lots at their asphalt concrete plants in Savannah and Augusta. After almost a year of construction traffic, these test sections performed satisfactorily. As a result, the Georgia DOT approached the contractor about placing test sections on one mile of State Route 21 in Effingham County and on widening and reconstructing a 1,500 foot stretch of Chatham Parkway in Chatham County.

The mixture was produced from APAC's asphalt plant in Savannah, and 5% recycled shingles were added to the mix in the same manner as reclaimed asphalt pavement (RAP) material would be added to the mixture. To ensure adequate dispersion of the shingle material, shingles were transported to a sister manufacturing plant in Maryland for shredding (since no shredding facility was locally available) to a maximum of 1/2" size chips and transported back by rail to Savannah and stockpiled at APAC's asphalt plant. Production and placement of the recycled shingle materials went well with no noticeable problems in production, placement, or compaction of the mixtures.

The Chatham County project also allowed for evaluation of the shingles in the subsurface mix as well as the surface mix. Laboratory tests for Marshall stability, flow, tensile strength, and resistance to rutting as measured by the Georgia Loaded Wheel Tester, all indicated that the mixture with recycled shingles gave similar to slightly improved materials properties as compared to conventional asphalt mixtures.

The diversion of GAF's manufacturing scrap for beneficial use will save valuable landfill space with an estimated disposal cost savings of approximately $96,000 per year (based on disposal fees of $16.50 per ton and hauling costs). Replacement of conventional materials and conservation of natural resources is expected to save the manufacturer of the asphalt approximately $169,000 per year. Assuming shredding costs of $19,000, the net savings realized is $236,000 per year. This assumes all of the scrap generated at GAF each year is used to modify 110,000 tons of HMA at a rate of 5% by total weight.

C.W. Matthews, Inc., a HMA Contractor, has purchased equipment to remove nails and shred both manufacturing scrap and reroofing scrap. To prevent the stockpiled scrap shingles from "melting" together in the summer heat, a shed has been constructed to cover the stockpile and fine aggregate has been mixed with the ground shingles. The facility has already processed 200 tons, which have been used in HMA at a rate of 5% for a two mile stretch on the East West Connector in Cobb County. According to Pace Jordon, the owner, the results were

satisfactory. The facility can process 150,000 tons of asphalt shingle scrap per year. This amount can supply 15-20 HMA plants which can modify 2 million tons of HMA road pavement containing hot mix asphalt. This one facility can process 50% of the asphalt shingle scrap generated in the state. According to Dr. Brock of Astec Industries, Georgia would require only two such equipped facilities to process all the asphalt shingle scrap generated in the state for use in HMA. However, as haul distances increase, it may become more feasible and economical to have additional facilities.

In addition to recycling the asphalt shingle scrap into HMA, other recycling or reuse options exist in Georgia. Two shingle manufacturers in Georgia currently recycle approximately 12,000 tons of shingle tabs per year by either selling or giving away the material for rural driveways. The asphalt tabs are spread in driveways and simply compacted.

5.0 Factors Influencing the Viability of Recycling Asphalt Shingle Scrap

Asphalt shingle recycling in Georgia has been shown to be a cost effective management option for manufacturers of asphalt shingles and as an economical alternative to the use of virgin materials for hot mix asphalt plants. As disposal costs increase, there will be increasing economic incentives for those involved with construction and reroofing to separate and recover asphalt shingle scrap for beneficial use.

Field tests have been successfully conducted by the Georgia DOT in the Savannah area using manufactured asphalt shingle scrap in HMA. In addition, Georgia is one of nine states to have specifications that allow 5% manufactured or reroofing scrap to be added to HMA for use in road pavement.

Other factors that affect the viability of asphalt shingle recycling in Georgia include:

Sustainable Supply

The actual quantity of asphalt shingle scrap generated in Georgia is not known. Nor is it possible to guarantee that a specific quantity of scrap would be available for recycling. In addition, there are a number of factors that could affect the quantity generated in the future. These factors include:

- increase or decrease in manufacturing of asphalt shingles
- rate of new home construction
- average size (square feet) of homes constructed
- rate of renovation and demolition of homes
- occurrence of natural disasters

Georgia currently has five plants that manufacture asphalt shingles and produce scrap. NAPA estimates that scrap generation from the manufacturing of asphalt shingles is equivalent to 5% - 10% of the production rate. An increase or decrease in the production of asphalt shingles in the state would affect the amount of scrap produced from this source.

Based on U.S. Census Bureau information, between 1990 and 1996, the number of building permits issued in the state increased 82%. This boom in new construction is likely increasing the demand for asphalt shingles. Therefore, it may be that unlike many other parts of the country, in Georgia more shingles are used for new

construction than for reroofing. This trend may affect the applicability of NAPA's estimate that two-thirds of the shingles used are used for reroofing and the direct correlation between shingles used for reroofing and the generation of asphalt shingle scrap. As a result, asphalt shingle scrap generation may be significantly lower than estimated until some time in the future when the new roofs currently being constructed are replaced.

Renovation activity is high in some parts of the state, such as the historic area of Savannah. Building permits in Savannah and the lower coastal areas have risen 156% since 1990. In addition, demolition is still occurring in the Albany area as a result of the 1994 flood. In 1990, 92 demolition permits were issued in the Albany area, by comparison, 244 permits were issued in 1996. These activities have a direct affect on the quantity of asphalt reroofing scrap that is generated.

Quality of Supply

In theory, it is possible to incorporate all of the asphalt shingle scrap generated in the state into HMA. Achievement of this level of recycling is dependent in part on the ability to provide a supply of shredded material free of contaminants. Shredding (and decontamination) equipment necessary to reduce the size of the scrap for use in HMA is available and operational in the Atlanta area. Running at full capacity, this equipment has the capacity to shred half the asphalt shingle scrap estimated to be produced in the state. An additional facility, located in the central or southeastern

part of the state, would increase the percent of both manufactured and roofing scrap which could be shredded and made available for use in HMA.

Costs

Sources within Georgia familiar with asphalt shingle scrap recycling have indicated it is economically beneficial to recycle asphalt shingles when landfill tipping fees reach $20 - $30 per ton. Information obtained from asphalt shingle manufacturers in the state support this statement. For example, in the Savannah area firms are paying disposal fees of approximately $21 per ton and in Atlanta fees are approximately $27 per ton. For this reason, tabs produced during the manufacturing process are either given away or sold for paving rural driveways to reduce the asphalt shingle scrap being disposed in landfills.

According to information provided by local governments as part of the Department of Community Affair's Annual Solid Waste Management Survey and Full Cost Report, the average disposal fee at the municipal solid waste landfills in the state is $24.09 per ton, with the highest fee reported being $48.20 per ton and the lowest $1.00 per ton. However, costs such as those discussed below under market accessibility will also need to be taken into consideration when assessing the economic viability of recycling versus disposal of asphalt shingle scrap.

Market Accessibility

Probably the single greatest impediment affecting the quantity of asphalt shingles that are currently being recycled is the lack of infrastructure to collect and transport asphalt shingle scrap from the point of generation to the shredding facility and subsequently to a hot mix asphalt plant. If collection points were to be developed, consideration would need to be given to such issues as ownership, staffing and handling procedures. For example, scrap piles would need to be covered and fine aggregate mixed with the shingles to prevent them

from sticking together. The development of such collection points will add to the cost of recycling asphalt shingle scrap and will need to be taken into consideration when evaluating the cost of recycling versus the cost of disposal. Transportation of the asphalt shingles from the collection points to the existing or a new shredding facility and from the shredding facility to a hot mix plant also adds cost to the recycling of this material.

6.0 Encouraging Asphalt Shingle Recycling in Georgia

To encourage the recycling of asphalt shingle scrap, education of the major stakeholders is needed to promote the opportunities for asphalt shingle recycling in Georgia. In addition, a technical assistance program could be developed and targeted toward building contractors, hot mix asphalt plant managers, construction engineers, road contractors, manufacturers of asphalt shingles, and state and local government officials. The technical assistance program would focus on communicating the environmental and economic benefits of recycling asphalt shingles in Georgia. If a state technical assistance program is developed, it would be beneficial for the program to be incorporated as a part of the Pollution Prevention Assistance Division's solid waste reduction technical assistance program in partnership with the Environmental Protection Division and the Georgia Department of Transportation.

Networks exist within the state for the dissemination of technical assistance material. Builders can be reached through the Home Builders Association of Georgia, which has 35 affiliates located around the state. The Greater Atlanta Home Builders Association includes builders in the 20 county Atlanta metropolitan area. The National Association of Home Builders and Keep America Beautiful, Inc. have developed a joint project targeted toward encouraging waste reduction and recycling among home builders. Information about asphalt shingle recycling could be included in the materials available for this program and distributed through the Georgia Clean and Beautiful system. Currently, Georgia Clean and Beautiful has affiliates in 57 counties covering 73% of the state's citizens. Local government officials can be informed of the benefits of asphalt shingle recycling through the Association County Commissioners of Georgia (ACCG) and the Georgia Municipal Association (GMA).

P^2AD partners with Georgia Institute of Technology's Economic Development Institute (EDI) and the University of Georgia's Department of Biological and Agricultural Engineering (BAE). Currently, this partnership, referred to as the Georgia Environmental Partnership (GEP), provides technical assistance to industry on pollution prevention and waste reduction through EDI's 18 regional offices situated throughout the state and by technical staff of BAE. Workshops are held throughout the year to train personnel of both EDI and BAE to perform technical assessments for businesses in their regions. Material and training on asphalt shingle recycling can be provided to the technical staff of both EDI and BAE through the GEP for dissemination to builders in the state. Likewise, the Cooperative Extension Service operated through the University of Georgia can serve to distribute this information through the county extension offices.

Habitat for Humanity, which has 65 affiliates in Georgia and a global reach, is another organization through which a program for asphalt shingle recycling can be promoted. Habitat is working to design homes to produce minimal waste and reuse and recycle what waste is produced. During their recent 20 home Building Blitz in Americus, Georgia in 1996, asphalt shingles were not among the materials recycled.

The majority of hot mix asphalt plants in the state are members of the Georgia Highway Contractors' Association. Their participation would also benefit any technical assistance program designed to encourage asphalt shingle recycling.

Errata

The value of the shredding cost on page 13 was inaccurately reported as $19,000. The correct value for the shredding cost is $29,000. The shredding cost was derived from adding the disposal cost savings and the manufacturers' savings from conservation of natural resources and replacement of conventional materials and subtracting the net saving realized. The expression with the actual values reported in the case study is as follows:

($96,000 + $169,000) - $236,000 = $29,000.

It should also be noted that the values on page 12 and 13 of the report were taken from a Department of Transportation study that was conducted approximately four years ago. Since it is possible that these estimates for the costs and savings used in this study have changed, it has been suggested in the report that a pilot project be conducted to provide a better understanding of the true costs and savings associated with recycling asphalt shingles.