Case Study: Roofing Shingle Scrap in Hot Mix Asphalt, TxDOT Dallas District

Project Overview

In 1997, TxDOT tested two 1,000-foot sections of roadway using a Type C asphalt mix with AC 20 and roofing shingles. One section contained five percent post-industrial waste and the other used five percent postconsumer scrap. A control section was also constructed to monitor significant deviation in performance from the conventional highway surface. The study showed that shingles are a viable component of HMA.

Construction began on May 1, 1997, and ended on May 4, 1997. The average temperature during construction was 85° F with a trace of rain observed the night of May 5, 1997.

The project site, located on westbound SH 31 in Corsicana, Navarro County in the Dallas District, is a divided two-lane highway with a lane width of 12 feet. Both post-consumer and post-industrial roofing shingles were used in the HMA surface (Item 340), and the control mix was QC/QA. The reference marker location for the sections and test section plan is shown in Table 1 and Figure 1 respectively.

Table 1. Reference Marker Location

Section	Begin	End
Section 1	616-0.36 mile	616-0.55 mile
Section 2	616-1.31 mile	616-1.50 mile
Section 3	616-0.55 mile	616-1.31 mile

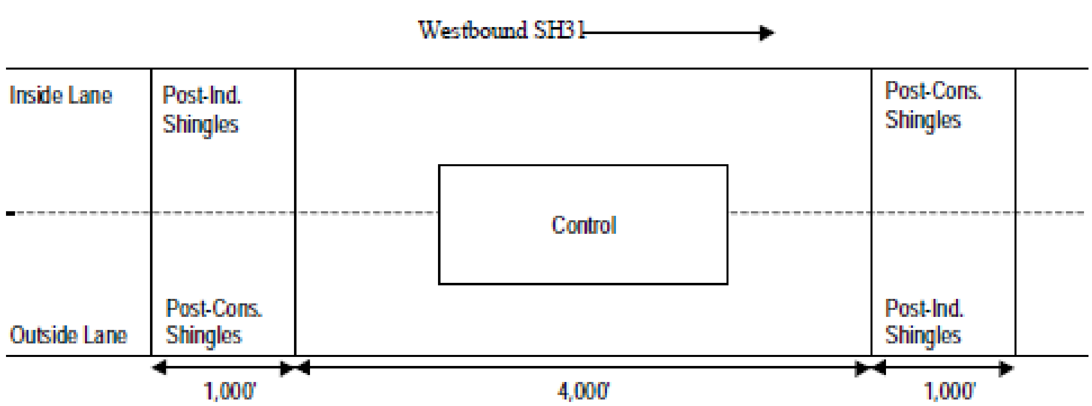

Figure 1. Test Section Plan

Each mix was poured on equally travelled lanes to provide consistent performance data. The estimated average daily traffic was between 4,500 and 4,700.

TxDOT’s recycled shingles project involved approximately 600 tons of mix used for each 1,000-foot test section, with 18 tons of tear-off waste for one section and 18 tons of manufactured waste for the second.

Thelin Recycling Company supplied a total of 60 cubic yards of processed shingles for this project. The sources of origin for the shingles were Owens-Corning Manufacturing and post-consumer roofing tear-offs.

Processing requirements for roofing shingles

Scrap shingles must be reduced in size prior to introduction into the mix. A schematic diagram of a two-stage shredding system is shown in Figure 2. The two-stage system consists of a primary feeder that delivers shingles into a large horizontal shaft impactor, which is a primary crusher. The primary crusher shreds the shingles down to about 50 mm (2 in). As the shingles move up a belt conveyer, a magnet removes any nails. The product then passes under a suction device that removes paper and other lightweight contaminants, while catching dust and airborne particles.

The shredded shingles are then fed onto an incline vibrating screen through which smaller material can pass. Material larger than 50 mm is fed back into the primary crusher, and the smaller material is fed onto a belt conveyor that leads to a secondary horizontal shaft impactor. This machine is designed with breakers and operates at high speed reducing the product to less than 12.5 mm (.5 in) in size. The newly crushed material is sent back to the screening unit where it is then fed onto a conveyor leading to a surge hopper automatically controlled by a blending system. There the shredded shingles are conveyed to a pugmill and mixed with sand or screenings and fed to a radial stacker for stockpiling (NAPA, 1997).

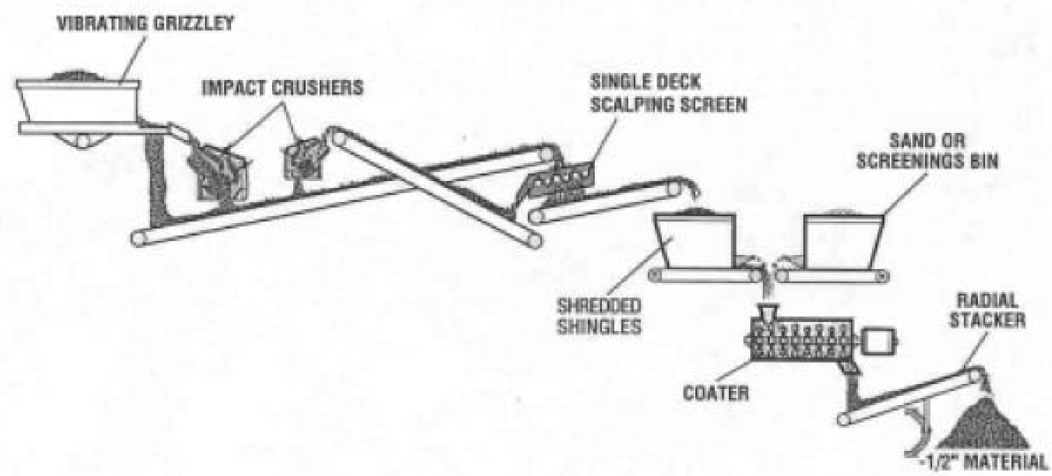

Figure 2. The Two-Stage Shingle Shredding System (NAPA 1997)

Construction techniques

The roofing shingles were stockpiled prior to construction and fed through the RAP collar at the hot mix plant. Hot mix was hauled to the project site, where the roadway was paved, compacted, and finally opened to traffic. The temperature was increased 25° F higher than the conventional HMA mixing temperature (Kosse, 1998). The shingles completely melted and dispersed uniformly into the HMA and no rejuvenating oil was needed to soften relatively hard post-consumer roofing shingles.

Specifications

This project used TxDOT Special Specification Item 3028, Hot Mix Asphalt Concrete Pavement Containing Reclaimed Roofing Shingles.

Test Data

Physical and chemical characteristics of roofing shingles: Shingles have a specific gravity of 2.651. Roofing shingles are typically comprised of approximately 35 percent asphalt, 45 percent sand, and 20 percent mineral filler (Newcomb et al. 1993). Due to aging, post-consumer shingles contained stiffer asphalt cement (Table 2).

Table 2. Constituents of Roofing Shingles Used in Corsicana Project

	Post-Consumer	Post-Industrial
Asphalt Cement (%)	25.1	22.3
Mineral Filler (%)	39.2	50.1
Viscosity of Asphalt (140° F)	37785 poises	12234 poises
Penetration @ 77° F (0.1 mm)	24.0	37.0

Table 3. Gradation of Roofing Shingles (Retained on Sieve)

Shingle Type	7/8"	5/8"	3/8"	#4	#10	#40	#80	Pan
Post-Consumer	0.0	0.0	2.1	2.9	2.9	43.4	9.5	39.2
Post-Industrial	0.0	0.0	1.4	0.8	1.1	35.3	11.3	50.1

Mix Design Information:

Materials Data

Table 4. Aggregates Used in Mix

Section Type	Smith/Bullard Type C (%)	Smith/Bullard Type D (%)	Smith/Bullard Screenings (%)	Trinity Field Sand (%)	Shingles (%)
Post-Consumer	21	39	29	6	5
Post-Industrial	21	39	29	6	5
Control	22	39	33	6	0

Table 5. Gradation of Mix Design (Cumulative Pass)

Shingle Type	1"	7/8"	5/8"	3/8"	#4	#10	#40	#80	#200
Post-Consumer	100.0	100.0	98.8	76.5	50.4	33.8	19.8	8.1	3.7
Post-Industrial	100.0	100.0	98.8	76.5	50.5	34.0	20.5	8.6	4.0
Control	100.0	100.0	99.5	74.0	46.5	31.9	20.6	12.7	6.3

Table 6. Asphalt Contribution in Mix Design

Mix Type	From Shingles	Virgin Asphalt
Post-Consumer Shingles	1.3	3.6
Post-Industrial Shingles	1.1	3.4
Control	0.0	4.6

Laboratory mix designs showed a higher binder contribution from the post-consumer shingles as shown in Table 6. Including a higher percentage of asphalt was a common manufacturing practice in the old days.

However, construction experience on this test project showed, due to the higher stiffness of the asphalt cement, the additional binder content in post-consumer shingles may not directly translate to an equal reduction in the quantity of new binder needed for the mix.

The gradation of the aggregate filler was slightly coarser in post-consumer shingles, but both gradations were well within the fine-aggregate gradation bands (Table 3).

Hveem stability value from laboratory mix designs indicate that the strength of the shingle mix increased marginally. The values were well above the TxDOT-recommended value of 35. See Table 7(a).

In addition, when the TxDOT-recommended anti-stripping agent dosage was used, boil tests (Tex-530-C) for stripping susceptibility showed that all three mixes (post-consumer, post-industrial and control) produced no stripping. See Table 7.

Even though creep tests were not required under the Item 340 specification for mix design, TxDOT Special Specification Item 3000 (QC/QA) requirements were met for creep stiffness and permanent strain. However, the creep slope of the HMA containing shingles showed values higher than the maximum creep slope limits specified in the QC/QA specification. See Table 7(c).

Table 7. Anti-stripping Agent Used in Test Sections

Test Section	Name	Percent Used	Recommended Anti-Strip (%)
Post-Consumer	Perma Tac Reg.	1.0%	1.0%
Post-Industrial	Perma Tac Reg.	1.0%	1.0%
Control	Perma Tac Reg.	1.0%	1.0%

Laboratory Test Data from the Mix

Test Results at Optimum Density (96 percent) are as follows:

(a) Hveem Stability: 47 (post-consumer), 46 (post-industrial), and 48 (control)

(b) Moisture Susceptibility:

	Post-Consumer	Post-Industrial	Control
Standard Test	Tex-530-C	Tex-530-C	Tex-530-C
TxDOT Specification	10% (Max)	10% (Max)	10% (Max)
Test Result	0.0%	0.0%	0.0%

(c) TxDOT Static Creep:

	Post-Consumer	Post-Industrial
Creep Stiffness (PSI)	8,484	8,652
Permanent strain x 1,000 (In/In)	0.51	0.47
Slope of SS curve x 1,000,000 (In/In/Sec)	6.20	6.20

(d) Air Void Content: 4 percent for all mixes

(e) Voids in Mineral Aggregate: 15.4% (post consumer), 14.5% (post-industrial), and 15% control

Results

The performance of test sections containing roofing shingles is satisfactory. So far no major distress has been reported. Some reflective cracking has occurred, but this typically begins at the same age in other mixes, according to the TxDOT area engineer. Texas Tech and Dallas District personnel performed and analyzed falling weight deflectometer tests in the summer of 1998 (Figures 3 and 4). Pavement sections with roofing shingles did not deviate from the control section in terms of structural integrity.

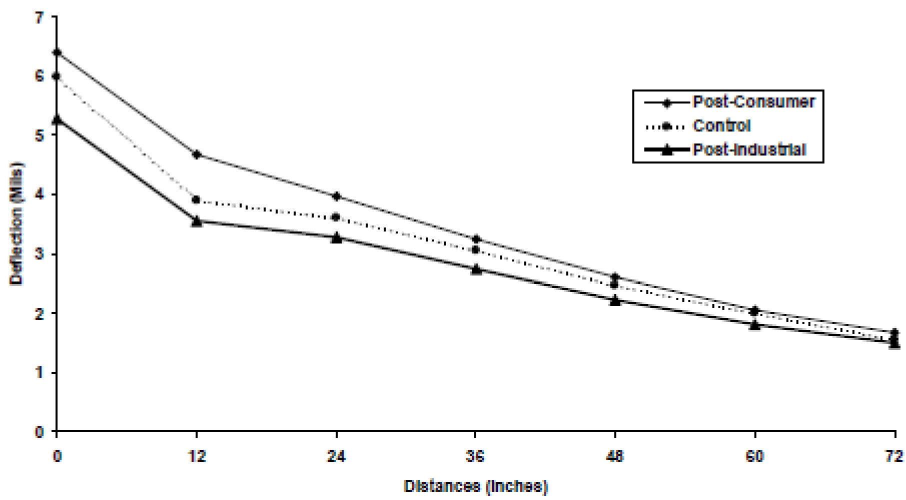

Figure 3. Outside Lane WP FWD Deflections (6,500 lb)
SH31, Corsicana, Shingles in HMAC

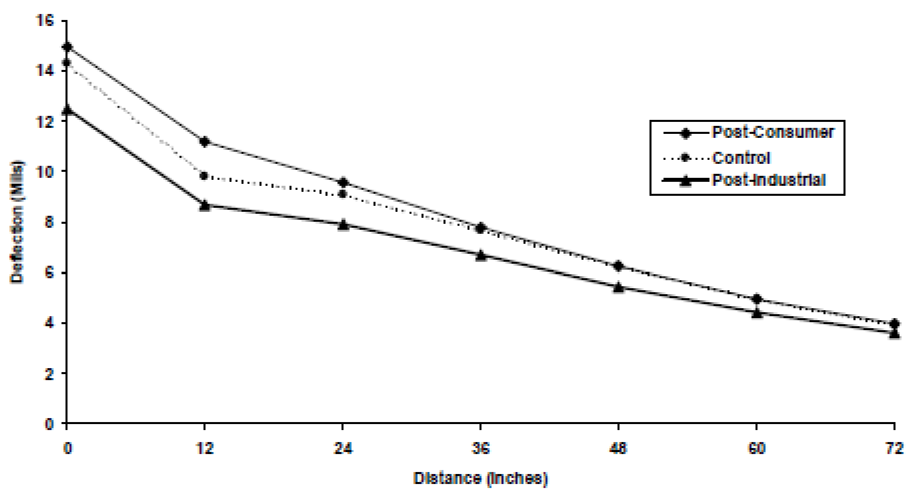

Figure 4. Outside Lane WP FWD Deflections (15,500 lb)
SH31, Corsicana, Shingles in HMAC

Roofing asphalt shingles appear to require more asphalt than anticipated, particularly with post-consumer shingles. The roofing felt lifted from the mix surface after the rollers' initial pass. This surfacing was a concern at first, but the roofing mix appeared identical to regular mix once it cooled, and the section was opened to traffic (Myers, 1998). Roofing shingles do not "clump" in stockpile as feared. They are very heavy (about 1,800 lbs/yd3), so transportation costs may be an important decision factor (Milner, 1998).

Post-consumer shingles seemed harder to handle than post-industrial shingles. These shingles have a thin polyethylene film, and pieces of it were released from the post-consumer shingles into the air from the conveyor belt that was feeding them into the hot mix drum. This, however, was a minor inconvenience primarily involving additional site cleaning that easily could be avoided. Experience, particularly with post-consumer shingles, indicates that a higher mixing temperature is needed to properly coat the material. The post-consumer shingle mix seemed too tender to roll, and felt came through the mat creating a soft area or hole. This mix appeared to be drier than the recycled new shingle mix, but there was no apparent softness on the paved surface once the section cooled (Kosse, 1998).

Economic Analysis

- **Cost of materials:** Roofing shingles cost $10 per cubic yard
- **Disposal cost of materials:** The disposal cost ranges from $30/ton to $55/ton