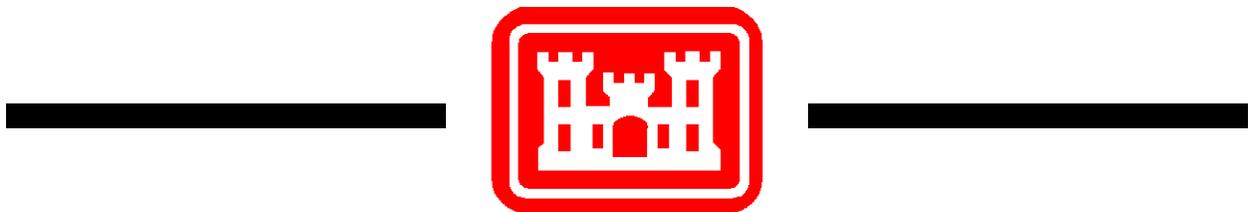


PUBLIC WORKS TECHNICAL BULLETIN 200-1-113
NOVEMBER 2011

**USING GROUND ASPHALT SHINGLES FOR
DUST CONTROL**



Public Works Technical Bulletins are published by the U.S. Army Corps of Engineers, Washington, DC. They are intended to provide information on specific topics in areas of Facilities Engineering and Public Works. They are not intended to establish new DA policy.

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314-1000

CECW-CE

Public Works Technical Bulletin

30 November 2011

No. 200-1-113

FACILITIES ENGINEERING
ENVIRONMENTAL
USING GROUND ASPHALT SHINGLES
FOR DUST CONTROL

1. Purpose.

a. The purpose of this Public Works Technical Bulletin (PWTB) is to transmit the results of a demonstration study conducted at Fort Hood, Texas. That study achieved two objectives: (1) to determine if ground, waste, asphalt shingles could be used to minimize dust generated on tank trails, and (2) to show that recycling waste asphalt shingles would be a cost-effective method to reduce the volume of solid material going to the landfill.

b. All PWTBs are available electronically at the National Institute of Building Sciences' Whole Building Design Guide webpage, which is accessible through this link:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability. This PWTB applies to all U.S. Army facilities where engineering activities have the responsibility to provide dust control and are responsible for the disposal of deconstruction waste.

3. References.

a. Executive Order (EO) 13101, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition," 14 September 1998.

b. EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," 5 October 2009.

c. Army Regulation (AR) 200-1, "Environmental Protection and Enhancement," 13 December 2007. (Available at: www.army.mil/usapa/epubs/pdf/r200_1.pdf.)

d. Clean Air Act and Amendments (CAAA), 15 November 1990.

4. Discussion.

a. EO 13101, Section 101, states that "the head of each executive agency shall incorporate waste prevention and recycling in the agency's daily operations and work to increase and expand markets for recovered materials through greater Federal Government preference and demand for such products."

b. EO 13514 requires that 50% of construction and demolition materials be diverted from landfills by the end of FY 2015.

c. AR 200-1 states, "The Army is committed to environmental stewardship in all actions as an integral part of its mission and to ensure sustainability". It supports the Army Strategy for the Environment, 1 October 2004, which presents the Army's environmental vision as sustainable operations, installations, systems, and communities enabling the Army mission (para 2-1a, 2-1b). It further states that all Army organizations and activities will comply with applicable Federal, State, and local environmental laws, regulations, EOs, or overseas Final Governing Standards (including standards for the control of particulate matter, established by the USEPA under the authority of the CAAA); develop and implement pollution prevention and control strategies; and establish environmental priorities in consideration of the benefits to the sustainment of missions and operations (para 2-2a).

d. The 1990 Amendments to the Clean Air Act of 1970: (1) established permit program requirements; (2) expanded and modified provisions concerning the attainment of National Ambient Air Quality Standards; and (3) expanded and modified enforcement authority.

e. Maneuver training activities can generate significant air quality impacts, particularly from the generation of dust when tactical vehicles drive over tank trails and dirt roads. Because of its close proximity to CAAA nonattainment zones, Fort Hood may be forced to reduce particulate emissions from its training areas or risk having combat training severely restricted.

f. Fort Hood recognized a need for treatments that can reduce dust generated from its tank trails and dirt roads, and learned that applying ground waste shingles to those roads had a huge potential to reduce dust pollution. Waste shingle reuse could help achieve compliance with EO 13514 by reusing a demolition waste, and at the same time help achieve Fort Hood's 25-year air quality goal to establish processes that will attain regional air quality and sustain military training.

g. A demonstration study was conducted at Fort Hood to explore the feasibility of using waste asphalt shingles in a combined mixture with recycled roadway asphalt as a surface cover on tank trails to minimize generated dust. This study was conducted under the Facility Modernization and Sustainability Program (FMSP) program managed by the Engineer Research and Development Center - Construction Engineering Research Laboratory (ERDC-CERL) in Champaign, IL. The study was conducted in 2006 by MSE Technology Applications, Inc. (MSE), of Butte, MT, the prime contractor for executing the FMSP program.

h. MSE explored the possibility of recycling waste asphalt shingles and determined through a literature review that grinding and mixing with recycled roadway asphalt to minimize dust pollution was a promising use to help Fort Hood meet sustainability goals. A plan was developed to segregate, grind, and mix approximately 15 tons of waste shingles with 585 tons of recycled road asphalt. This mixture was applied to a 700-ft section of 30-ft wide tank trail at a depth of 6 in. The actual handling costs for the asphalt shingles was significantly higher than found in the literature. It was found that although the mixed asphalt mixture was effective at reducing dust, a justification for using the mixture instead of recycled roadway asphalt alone cannot be made using the economics associated with the material handling costs of the asphalt shingles. A summary of the actual costs are shown in Table A-1 (Appendix A).

i. See Appendix A, "Grinding Waste Shingles for the Cleaner Air Project at Fort Hood," for further information regarding the Fort Hood study. Appendix A is the final report submitted by MSE to ERDC-CERL, edited for format and clarity.

j. A glossary of abbreviations is in Appendix B.

5. Points of Contact.

a. Headquarters, U.S. Army Corps of Engineers (HQUSACE) is the proponent for this document. The point of contact (POC) at

PWTB 200-1-113
30 November 2011

HQUSACE is Mr. Malcolm E. McLeod, CEMP-CEP, 202-761-5696, or e-mail: Malcolm.E.Mcleod@usace.army.mil.

b. Questions and/or comments regarding this subject should be directed to:

US Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
ATTN: CEERD-CN-E
2902 Newmark Drive
Champaign, IL 61822-1076
Tel. (217) 373-5831
FAX: (217) 373-3430
e-mail: Gary.L.Gerdes@usace.army.mil

FOR THE COMMANDER:



JAMES C. DALTON, P.E., SES
Chief, Engineering and
Construction Division
Directorate of Civil Works

Appendix A:

**GRINDING WASTE SHINGLES FOR THE
CLEANER AIR PROJECT AT FORT HOOD**

Foreword

This project was funded through the Facility Modernization and Sustainability Program (FMSP). The FMSP was administered by the U.S. Army Engineer Research and Development Center-Construction Engineering Research Laboratory. The study was conducted by MSE Technology Applications, Inc. (MSE), of Butte, Montana.

The major contributors to this project include:

- Mr. Jay McCloskey, MSE Project Manager
- Mr. Steve Antonioli, MSE Program Manager
- Mr. Jeff Salmon, Fort Hood, Texas
- Mr. Gary Gerdes, ERDC-CERL FMSP Program Manager

Table of Contents

Introduction.....	A-3
Background	A-3
Objectives	A-3
Approach	A-3
Alternate Uses for Waste Asphalt Shingles.....	A-4
Demonstration of Waste Shingles Mixed with Road Asphalt.....	A-5
Demonstration Design	A-7
Application of Waste Asphalt Shingles	A-8
Evaluation of Waste Asphalt Shingle Application	A-11
Cost Analysis of Waste Asphalt Shingle Application	A-13
Conclusions.....	A-14

List of Tables and Figures

Tables

Table A-1. Asphalt shingle material handling project costs..	A-14
---	-------------

Figures

Figure A-1. Aerial photo of South Range Road.....	A-6
Figure A-2. Project site along South Range Road.....	A-6
Figure A-3. Cross-section diagram of a typical primary tank trail.....	A-7
Figure A-4. Front loader mixing asphalt shingles and recycled roadway asphalt.....	A-9
Figure A-5. Belly-dump applying asphalt mix to tank trail... 	A-10
Figure A-6. Equipment spreading and compacting asphalt mixture. 	A-10
Figure A-7. Tank trail after asphalt mix installation.....	A-11
Figure A-8. Bradley tank traveling on existing tank trail... 	A-12
Figure A-9. Bradley tank traveling on asphalt shingle mix... 	A-12

Introduction

Background

Fort Hood, one of the largest Army installations in the United States, faces many challenges when it comes to maintaining a sustainable environment for training. Included in these challenges are compliance with Executive Order (EO) waste minimization requirements, and with the Clean Air Act and Amendments (CAAA). Armor training activities at Fort Hood can generate significant air quality impacts, particularly through dust from tank trails and dirt roads. Because of its close proximity to CAAA nonattainment zones, Fort Hood may be forced to reduce particulate emissions from its training areas or risk having maneuver training severely restricted. Fort Hood recognizes a need for treatments that can reduce dust generated during training exercises. Fort Hood's 25-year air quality goal is to establish processes that attain regional air quality and sustains military training.

In addition to supporting Fort Hood's future installation sustainability objectives, waste shingle reuse would assist compliance with EO 13514, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition." Currently, waste asphalt shingles from either demolition or deconstruction projects are sent to the landfill for disposal. Over 1 million square feet of housing is to be demolished/deconstructed at Fort Hood in the next few years. Waste shingles from demolition represent a huge potential resource for treating tank trails and dirt roads to reduce dust generation.

Objectives

The Grinding Waste Shingles for Cleaner Air Project at Fort Hood had two objectives. The first objective was to identify alternative uses for the waste asphalt shingles that also minimize the volume reporting to the landfill. The second objective was to determine the feasibility of grinding waste asphalt shingles and mixing with recycled roadway asphalt to minimize dust pollution at Fort Hood.

Approach

MSE conducted a literature review to investigate alternative uses of waste asphalt shingles. They then chose an application with considerable benefits for demonstration at Fort Hood, which was to mix the shingles with recycled roadway asphalt for covering tank trails to reduce dust pollution. A demonstration

was conducted at Fort Hood and a simple cost analysis was prepared.

Alternate Uses for Waste Asphalt Shingles

A literature review was conducted to investigate alternative uses for waste asphalt shingles and to evaluate application methods for the waste asphalt shingles. The review revealed that many organizations (e.g., states, universities, private business, and public) have performed relevant research or have experience in this area. Technical reports posted by the Construction Materials Recycling Association (CMRA n.d.) provided a significant amount of information. The information provided below is a brief discussion on alternative uses for waste asphalt shingles and some examples of costs associated with handling and processing the shingles.

In the United States, approximately 10 million tons of old asphalt roofing shingles (tear-offs) are removed from existing buildings each year (CIWMB 2001; Vermont ANR 1999). There are several potential markets for asphalt shingles, which include hot mix asphalt, cold patch, dust control on rural roads, temporary roads or driveways, aggregate road base, new shingles, and fuel (CMRA n.d.).

In all road applications, shingles must be shredded or ground for successful use. For hot mix asphalt (HMA) and cold patch, generally the smaller the shreds, the better they will be incorporated into the mix. HMA specifications written for the Texas Department of Transportation require that 100% of the shingle shreds pass the 19 mm ($\frac{3}{4}$ in.) sieve, and 95% pass the 12.5 mm ($\frac{1}{2}$ in.) sieve (CMRA n.d.). For road base applications, shingles are shredded to 1-1 $\frac{1}{2}$ -in. size and are mixed with aggregate at the appropriate ratio (CIWMB 2001). Generally, the cost of shredding/grinding increases as the required particle size decreases.

According to the literature, reusing scrap shingles is cost effective wherever landfill disposal costs are high. Demolition handling expenses for scrap shingles generally range from \$12 to \$14 per ton. Tipping fees at a shingle reprocessing plant (contractor's fee to accept and process shingles) can range from \$24 to \$45 per ton or higher for tear-offs from building demolition or roof replacement (Decker 2003). Thus the combined cost of handling and processing might be \$36-\$59 per ton. By contrast, tipping fees for landfill disposal can be in range from \$30-\$100 per ton of scrap shingles, depending on the area of the country.

A smaller amount of cost savings could occur if processed waste shingles are reused. A 1997 North Carolina study found that approximately \$1.13 per ton of HMA savings could be realized by incorporating 5% shingles into the mix (Vermont ANR 1999). This estimate was based on the prevailing average costs of HMA in North Carolina in 1997 and a \$50 per ton shingle processing fee. An average cost to produce HMA from virgin materials is \$200 per ton (Decker 2003).

The shingles available for this project were non-asbestos asphalt shingles from demolition work being performed on Fort Hood. The reuse alternative chosen was to use the asphalt shingles in a mixture with recycled roadway asphalt to cover tank trails. The expected benefits for this alternative were:

- avoiding disposal in the Fort Hood landfill, thereby extending the life of the facility;
- supplementing the volume recycled roadway asphalt available, thereby increasing the coverage of tank trails to be treated; and
- decreasing dust generation from the treated tank trails.

Demonstration of Waste Shingles Mixed with Road Asphalt

Fort Hood selected a site on the South Range Road for demonstrating the application of waste asphalt shingles mixed with recycled roadway asphalt. The waste asphalt shingles were ground using A Recyclone™ installed at Fort Hood. Figure A-1 is an aerial photo of South Range Road at Fort Hood and the project site is shown in Figure A-2.

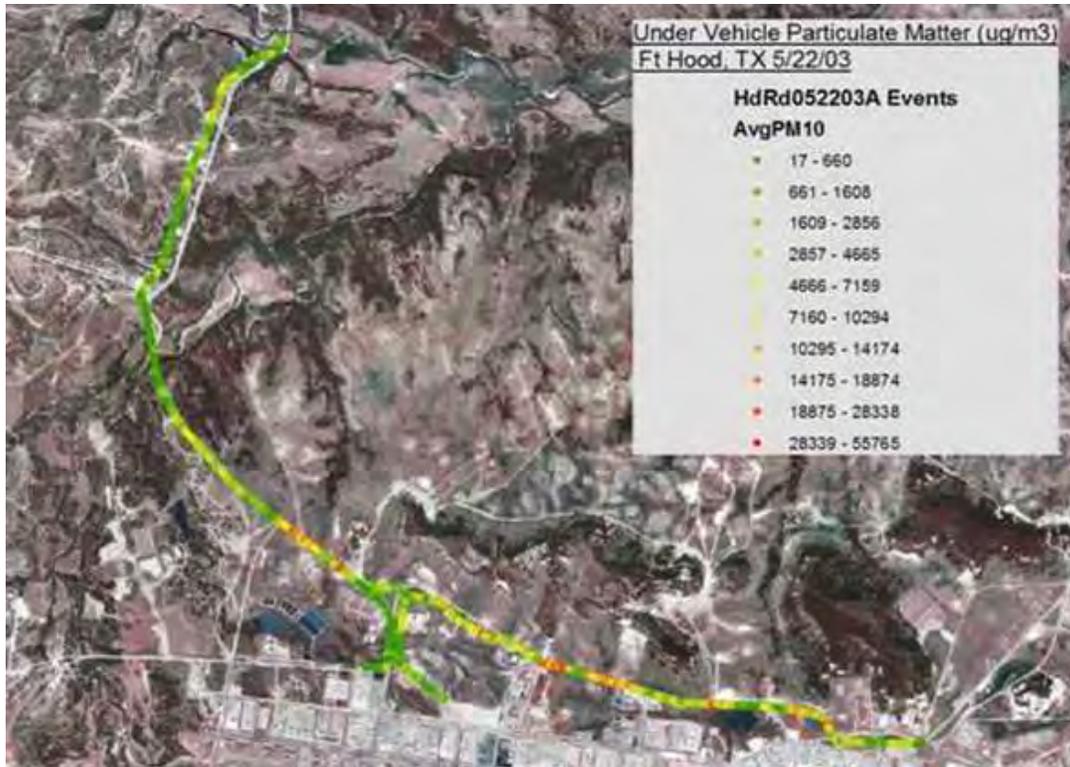


Figure A-1. Aerial photo of South Range Road.



Figure A-2. Project site along South Range Road.

Demonstration Design

Figure A-3 is a cross-section diagram of a typical two-lane primary tank trail construction for Fort Hood. Figure A-3 also shows a 6-in. asphalt mixture above the existing road base material. This was the original design approved by Fort Hood in April 2005, as discussed below.



Figure A-3. Cross-section diagram of a typical primary tank trail.

Plans called for covering 950 linear feet (ft) of tank trail was with a 6-in. depth of asphalt mixture. The width of the standard tank trail is 30 ft. It was assumed that a 6-in. road base and 6-in. lime stabilized subgrade is in place. It was also assumed that regrading and/or compacting would be necessary before applying the asphalt mixture. The asphalt mixture was to contain 5% waste asphalt shingles and 95% recycled road asphalt. Calculations completed in February 2005 estimated the total volume of asphalt mixture required to provide a 6-in. cover for 950-ft by 30-ft trail was 14,250 cu ft (ft³). Assuming typical

densities of 105 lb/ft³ for both the asphalt shingles and road asphalt, the amount of asphalt shingles required is 712.5 ft³ or 37.34 tons, and the road asphalt required is 13,537 ft³ or 720 tons. Both asphalt shingles and road asphalt were to be ground at the new Fort Hood grinding facility to a minimum size compatible with the grinder capabilities. As discussed, minus one-half inch was deemed acceptable. However, the size of the material would depend on the grinder capabilities. It was assumed that a larger size than minus one-half would be acceptable for this demonstration application. The asphalt shingles and road asphalt would be mixed in the ratio stated above. Mixing would be completed per the equipment and resources availability at Fort Hood. Two mixing options were available: (1) mixing through the grinder and stockpiling using a front-end loader or (2) mixing with a blade in rows.

Application of the asphalt mixture would be completed using a belly-dump truck, blade, and compaction equipment if necessary. Compaction of the road base would be performed with available equipment. To maintain through travel on the tank trail during application, one side or 15 ft would be installed followed by the other 15 ft of width. Installation would be completed per resource availability. Preparation of the existing road base and installation of the 6-in. asphalt mixture would be the responsibility of Fort Hood.

Application of Waste Asphalt Shingles

Approximately 700 ft on the tank trail along South Range Road was covered with a 6-in. asphalt mixture, which was the length of roadway determined necessary to demonstrate dust control. The original plan called for using 5% shingles in the mix; unfortunately, not enough waste shingles were available to cover 700 ft. of roadway with that mixture. The actual application of the 6-in. asphalt mixture cover used a total of 600 tons of ground material. Approximately 2.5% (15 tons) was waste asphalt shingles, and 97.5% (585 tons) was recycled road asphalt.

Waste shingle grinding was completed in early summer of 2006. The waste asphalt shingles had to be ground with the recycled road asphalt to minimize plugging, sticking, and gumming-up of the grinder. Shingle pieces 2-in. in diameter were visible in the mixture.

An area contractor was hired to: (1) mix the waste asphalt shingles with the recycled road asphalt at the final selected ratio of 2.5% waste asphalt shingles to 97.5% recycled road asphalt; (2) haul the mixture to the project site; (3) spread

the mixture on the tank trail per design (i.e., 30-ft width, 700-ft length, and 6-in. depth); and (4) compact mixture using a roller equipped with vibrator capabilities. The contractor completed the installation by the end of the week.

Figure A-4 is a photo of a front-end loader mixing the asphalt shingles and recycled roadway asphalt. Figure A-5 is a photo of the asphalt mixture being applied to the tank trail. Figure A-6 shows the equipment spreading and compacting the asphalt mixture, and Figure A-7 shows the tank trail after the asphalt mixture was installed.



Figure A-4. Front loader mixing asphalt shingles and recycled roadway asphalt.



Figure A-5. Belly-dump applying asphalt mix to tank trail.



Figure A-6. Equipment spreading and compacting asphalt mixture.



Figure A-7. Tank trail after asphalt mix installation.

Evaluation of Waste Asphalt Shingle Application

The primary purpose for installing a non-dusting material on the tank trails at Fort Hood is to minimize the dust loading resulting from vehicles driving on the tank trails. Relative success of the control method was determined visually. Figures A-8 and A-9 show the positive results of using the asphalt shingle mixture on the tank trails. Fort Hood has used recycled roadway asphalt (without recycled shingles) to cover additional sections of tank trails and lots used for tanks and other associated military equipment. The use of recycled asphalt appears to be very effective at reducing dust generation (with or without recycled shingles).



Figure A-8. Bradley tank traveling on existing tank trail.



Figure A-9. Bradley tank traveling on asphalt shingle mix.

Cost Analysis of Waste Asphalt Shingle Application

The waste shingles used for the demonstration came from building demolition, so additional work had to be performed at the demolition site to tear off the shingles and segregate them from other demolition wastes. The cost to tear-off, segregate, and haul 15.3 tons of asphalt shingles to the landfill was \$9,800. The Fort Hood Recyclone™ equipment was used for approximately 16 hr to grind the asphalt shingles at the Fort Hood landfill. Two operators were needed to process the shingles (one each for Recyclone™ and front-end loader). Assuming a total operating cost of \$250 per hour for labor and equipment, the total cost to grind the shingles was estimated at \$4,000. Recycled roadway asphalt had to be ground with the asphalt shingles to improve throughput and to minimize clogging and plugging. A front-end loader was used to make the mixture (see Figure A-4). Approximately 4 hr was required to mix the material. The combined cost of the loader and operator were \$100 per hour; therefore, the estimated cost to mix the material was \$400. Thus the total material handling costs associated with recycling the waste asphalt shingles was \$14,200.

Table A-1 is a list of associated project material handling costs for the asphalt shingles for this demonstration, which equates to approximately \$930 per ton. It should be noted that if the waste shingles had come from a reroofing project, the cost for tear-off and segregation would be inherent to the roofing project and would not be considered a recycling cost. Total handling costs would probably have been about \$300 per ton if the shingles came from reroofing instead of building demolition. Still, the handling cost is significantly higher than the cost cited in the literature review and do not compare favorably even with virgin hot mix asphalt costs. Some of the higher cost can be attributed to the small amount of asphalt shingles processed and using multiple contractors to do the material handling and processing. However, the actual costs incurred by this project indicate that the full-scale handling and processing cost would still be significantly greater than the worst case, \$100-per-ton landfill disposal cost cited in the literature.

Table A-1. Asphalt shingle material handling project costs.

Operation	Cost
Tear-off, segregate, haul, and store	\$9,800
Grinding (labor & equipment)	\$4,000
Mixing (labor & equipment)	\$400
Total	\$14,200

Conclusions

Using recycled roadway asphalt to cover additional sections of tank trails and lots used for tanks and other associated military equipment appears to be very effective at reducing dust generation. However, recycling the tear-off asphalt shingles does not appear to be cost effective at Fort Hood. The cost per ton to recycle the shingles appears to far exceed any reasonable landfill disposal fee. Even if a more efficient system was developed for handling, grinding, and mixing the waste shingles, the unit cost for utilizing tear-off asphalt shingles in a mixture with recycled roadway asphalt would still be much more than the unit cost for recycled roadway asphalt alone. Therefore, a justification for mixing tear-off asphalt shingles with the recycled roadway asphalt cannot be made using the economics associated with the material handling costs of the asphalt shingles.

Appendix B:

ACRONYMS AND ABBREVIATIONS

Term	Spellout
ANR	Agency of Natural Resources
AR	Army Regulation
CAAA	Clean Air Act and Amendments
CERL	Construction Engineering Research Laboratory
CFR	Code of the Federal Regulations
CIWMB	California Integrated Waste Management Board
CMRA	Construction Materials Recycling Association
DA	Department of the Army
EO	Executive Order
ERDC	Engineer Research and Development Center
FMSP	Facility Modernization and Sustainability Program
HMA	Hot mix asphalt
HQUSACE	Headquarters, U.S. Army Corps of Engineers
MSE	MSE Technology Application, Inc
n.d.	no date available
PDF	Portable Document Format
PM	Particulate matter
POC	point of contact
PWTB	Public Works Technical Bulletin
URL	Universal Resource Locator
USEPA	United States Environmental Protection Agency
WWW	World Wide Web

Appendix C:

REFERENCES

- Construction Materials Recycling Association (CMRA). n.d.
<http://www.shinglerecycling.org/content/markets-recycling-asphalt-shingles> (accessed April 2010).
- California Integrated Waste Management Board (CIWMB). 2001.
Asphalt Roofing Shingles Recycling: Introduction. Available at: <http://www.p2pays.org/ref/34/33792.pdf> (accessed April 2010).
- Decker, D. July 2003. *Paying Off*. Recycling Today. Available at: http://www.recyclingtoday.com/Article.aspx?article_id=18749 (accessed April 2010).
- Vermont Agency of Natural Resources (Vermont ANR). September 1999. *Recycled Asphalt Shingles in Road Applications: An Overview of the State of Practice*. Available at: <http://www.anr.state.vt.us/dec/wastediv/recycling/shingles.pdf> (assessed April 2010).

(This publication may be reproduced.)