DEVELOPING IMPROVED OPPORTUNITIES FOR THE RECYCLING AND REUSE OF MATERIALS IN ROAD, BRIDGE, AND CONTRUCTION PROJECTS

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Disclaimer

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation.

Metric Conversion Table

SI* (MODERN METRIC) Conversion Factors

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
^{o}F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^{o}C

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
^{o}C	Celsius	1.8C+32	Fahrenheit	^{o}F

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
lx	Lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
N	newtons	0.225	Pound force	lbf
kPa	kilopascals	0.145	Pound force per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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16. Abstract The use of recycled and reused materials in transportation construction reduces consumption of non-renewable resources. The objective of this research was to develop opportunities for improving the recycling and reuse of materials in road and bridge construction. A number of strategies were developed for improving the use of recycled and reuse materials. Specific recommendations were made and implementation issues were discussed.		
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Executive Summary

This research project was focused on developing strategies for improving opportunities for recycling and reuse of materials in road and bridge construction on FDOT projects. The use of recycled and reused materials reduces the consumption of the limited supply of non-renewable resources. The project effort was organized into five tasks:

1. Conduct a literature review and examine current industry practice
2. Develop a characterization of waste materials from FDOT construction projects
3. Identify and interview experienced industry professionals concerning reuse and recycling
4. Using an industry focus group, develop strategies to improve reuse and recycling of waste materials from the FDOT construction program
5. Create a comprehensive Final Report of the research effort and findings

A comprehensive review of literature and industry practice was conducted to determine current knowledge and practice in the subject area. This included a review of all relevant research reports and published articles in the subject area. Additionally, each state highway agency was contacted to obtain specific information on their recycling and reuse activities. The results of that survey are provided in Appendix A of this report.

Developing a clear understanding of the engineering properties of candidate recycled materials is a prerequisite to developing uses for recycled materials. Therefore, a comprehensive analysis of laboratory testing reports concerning recycled materials was conducted. This information is included in Section 3 of this report.

Structured interviews were conducted with industry professionals from the recycling industry, construction contractors and FDOT construction engineers. The purpose of this activity was to determine the current state of practice with regard to the recycling of construction materials and gain insight into economic factors that influence the industry. The results of the industry interviews are presented in Section 4 of this report.

A focus group of members from the recycling industry, construction contractors and FDOT engineers was formed to develop specific strategies for improving recycling and reuse on FDOT construction projects. The following strategies were ultimately recommended for implementation:

- On FDOT projects with structural demolition, require that demolished concrete be delivered to a recycling facility
- Require that mix designs for non-structural concrete must utilize recycled concrete aggregates
- In Design-Build Project RFP under the typical section “Evaluation Criteria”, subsection “Design”, include in the list of elements to be considered “Design Considerations that Improve Recycling and Reuse Opportunities”
- Provide a link to the current recycling web page on the home pages of the State Materials Office, Construction Office and Design Office. Add additional content (recycling updates, project show case, news)
- Implement a research initiative to develop an engineering specification for the use of RAP material as a surfacing for low volume roads

- In Design Consultant Procurement under the “Evaluation Criteria”, subsection “Approach”, include in the list of elements to be considered “Design Considerations that Improve Recycling and Reuse Opportunities”

Implementation of these measures will improve opportunities for the use of recycled and reuse materials in the FDOT construction program.

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1. Introduction

The Florida Department of Transportation (FDOT) is committed to protect and enhance a sustainable human and natural environment while developing safe, cost effective, and efficient transportation systems. Recycling and reuse of waste materials is widely recognized as an essential component of environmental stewardship. The FDOT has engaged in a number of technical research studies with the objective of developing sound methodologies for incorporating recycled and reused materials. Technical solutions are necessary to assess the efficacy of recycled materials in new construction, but technical solutions do not appear to be the complete answer. A more complete understanding of the business considerations that influence private sector participants is needed. The objective of this research study was to develop recommendations for increasing the reuse and recycling of waste materials from the FDOT construction program.

The work on this project was divided into the following five tasks:

1. Conduct a literature review and examine current industry practice
2. Develop a characterization of waste materials from FDOT construction projects
3. Identify and interview experienced industry professionals concerning reuse and recycling
4. Using an industry focus group, develop strategies to improve reuse and recycling of waste materials from the FDOT construction program
5. Create a comprehensive Final Report of the research effort and findings

2. Review Literature and Current Practice

2.1 Literature Review

2.1.1 Introduction

This section of the report presents the results of narrowly focused literature review and industry survey examining the state of recycling practices of other state transportation departments in the United States. The literature review includes research reports, published journal articles and other electronically published materials. Each state Department of Transportation (DOT) was contacted to obtain current information concerning their reuse and recycling efforts.

2.1.2 Reclaimed Asphalt Pavement (RAP)

The United States has over 2 million miles of paved roads with over 90% being surfaced with asphalt pavement. Road maintenance requires the milling and replacing of these asphalt surfaces. These millings create a binder coated aggregate known as reclaimed asphalt pavement (RAP). A portion of the RAP can be added directly into the new hot mix asphalt to be installed on roadways. However, there are limitations to how much RAP can be used in asphalt pavement mixes. Consequently, RAP stockpiles are growing in Florida (Cosentino and Kalajian 2001) (Cosentino et al 2008).

Currently all states have approved some level of RAP in their mixes, with varying success rates in each state. Figures 1, 2 and 3, and Table 1 illustrate the current usage of RAP in each state in the United States.

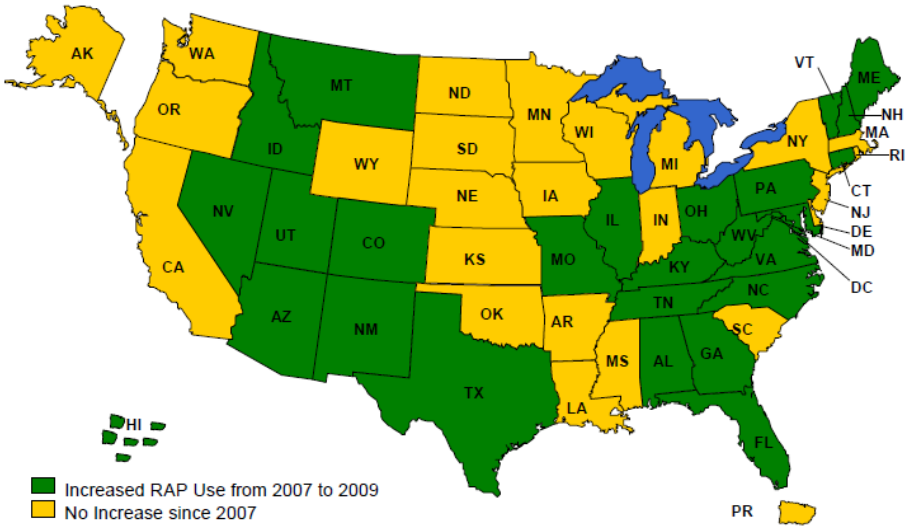

Figure 1: States with increased RAP use since 2007

(Copeland 2011)

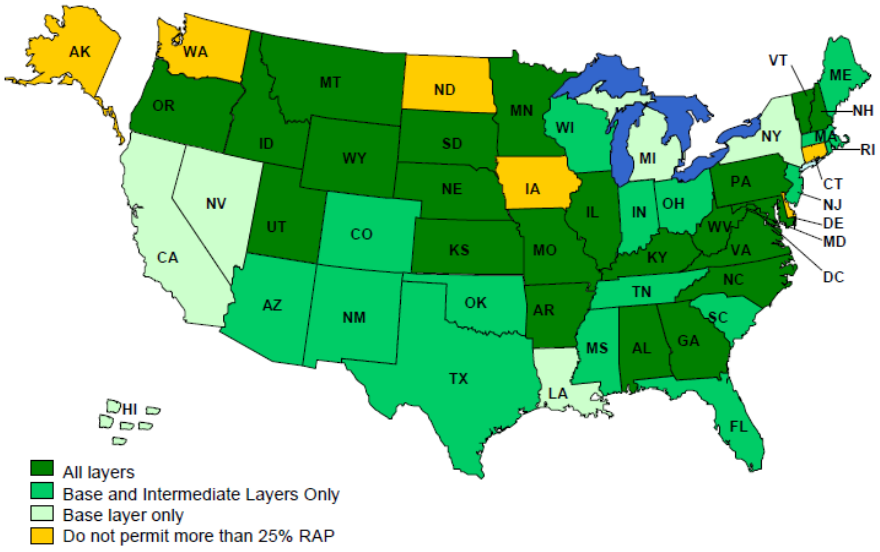

Figure 2: States that permit more than 25% RAP in HMA pavement

(Copeland 2011)

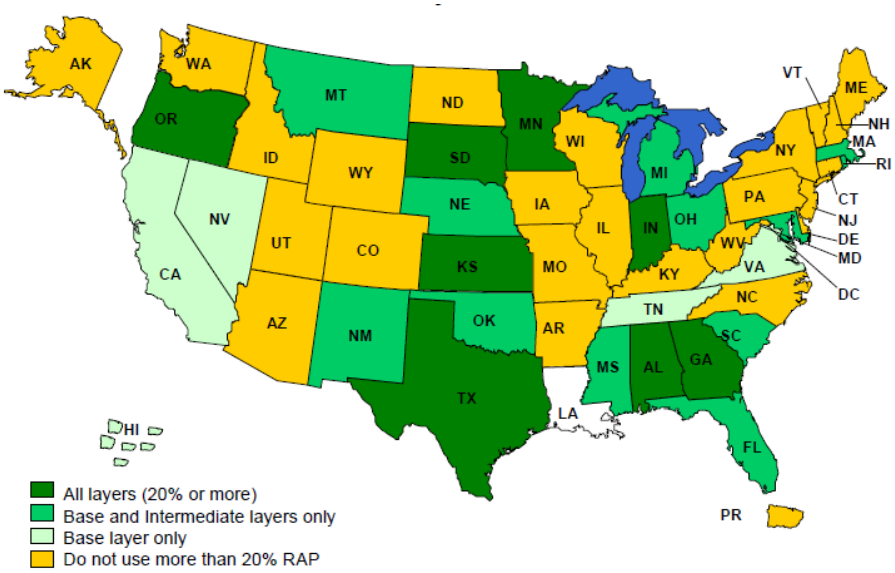

Figure 3: States with more than 20% RAP usage in HMA pavement (Copeland 2011)

Currently the state of Florida has permissive specifications regarding RAP and has been increasing the allowable use of RAP since 2007. In 2002, the FDOT published a report evaluating two projects which were constructed using hot-in-place recycling technology. One was constructed with in-place millings and the other required scarification. The in-place milling project began to crack two weeks after completion, and 50% of the project had cracking and delamination after several more weeks. The project which utilized scarification did not crack and delaminate as quickly, but the ride quality was subpar to conventional hot-mix asphalt paving (Sholar et al. 2002).

Table 1: Percentage of RAP Permitted by Each State DOT
(Stroup-Gardiner and Wattenberg-Komas 2013)

State	Lift		
	Wear	**Binder**	**Base**
DE	NS	NS	NS
IA	NS	Limited to 30% max binder contribution from RAP, 10% RAP mix for unknown RAP source	NS
IL	Varies	Varies	Varies
LA	NS	NS	NS
MO	NS; not allowed in SMA	NS	NS
ND	NS	NS	NS
PA	NS	NS	NS
SC	Varies	Varies	Varies
WV	Skid resistance requirements limit use in wear course	Varies	Varies
KY	% unlimited unless RAP contains PG76-22 when max is 20%	% unlimited unless RAP contains PG76-22 when max is 20%	% unlimited unless RAP contains PG76-22 when max is 20%
DC	0	NS	NS
ID	0	Varies	Varies
KS	0	NS	NS
OK	0	15	
MA	10	40% with drum mix plant; 20% with modified batch plant	40% with drum mix plant; 20% with modified batch plant
CT	15	15	15
FL	15	No restriction	No restriction
IN	15	25	25
ME	15	25	25
NJ	15	25	25
NM	15	35	35
AL	20	25%; 35% with warm mix technology	25%; 35% with warm mix technology
CO	20	25	25
HA	20	30	30
MD	20% with no change in fresh binder grade	25% with no change in fresh binder grade	25% with no change in fresh binder grade

NS = RAP is used but amount not indicated in response; SMA = Stone mix asphalt; OGFC/PEM = open-graded friction course/porous European mix

Table 1, continued

State	Lift		
	Wear	**Binder**	**Base**
NY	20	20	30
OH	20; more if warm mix technology is used	20; more if warm mix technology used	50
OR	20	30	30
TX	20% fractionated RAP 10% unfractionated	30% fractionated RAP; 20% unfractionated	40% fractionated RAP; 30% unfractionated
WS	20	20	20
MS	25	30	30
UT	25	20	20
MN	30	40	40
GA	40; no RAP in SMA or OGFC/PEM	40	40
NC	50% max; 15% to 25% typical	50% max; 15% to 25% typical	50% max; 15% to 25% typical
VT	50% upon mix design approval	50% upon mix design approval	50% upon mix design approval

NS = RAP is used but amount not indicated in response; SMA = Stone mix asphalt; OGFC/PEM = open-graded friction course/porous European mix

In 2006, the FDOT funded a forensic investigation of State Road 471, a hot-in-place recycled project constructed in Sumter County, Florida. This project evaluated a 5 mile stretch of road which was constructed using hot-in-place recycling. Within 6-12 months of the road being completed, rutting began to occur, and the FDOT funded the investigation to understand why. The investigation was not able to irrefutably determine which layer of the pavement caused the rutting (Hammonds and Greene 2006).

In 2007, a project report was published evaluating the use of high percentage of RAP. Rutting and cracking testing was done for mixtures containing 0%, 25%, 35%, and 45% RAP. This study found that generally rut depth decreases as the amount of RAP increases, but when compared to the control mixture, RAP mixes showed more and/or similar rut depth from using

the lower high temperature PG grade virgin binder. The cracking performance of RAP mixtures decreased even with softer binder as the amount of RAP increased (Kim et al. 2007).

In 2009, the FDOT published a report of laboratory evaluation of polymer modified asphalt mixture with reclaimed asphalt pavement. This report analyzes rutting and cracking performance of RAP mixtures with styrene-butadiene-styrene polymer modified binders as their virgin binders with varying amounts of RAP. The rut test did not show significant differences in the performance of the differing amounts of RAP with the polymer modified binder. Tensile strength increased slightly but not significantly from the Superpave IDT test. All of the RAP mixtures were found to perform well in the Superpave IDT test (Kim et al 2009).

In 2011, the FDOT examined high RAP asphalt performance again. A trend was found showing decreased age to deficiency as the percent RAP increased, and with projects ≥5000 tons, there was a trend of decreasing performance with increasing amounts of RAP. However, all mixtures containing RAP performed better than those containing no RAP (Nash et al 2011).

2.1.3 Crushed Concrete

Crushed concrete is a commonly recycled construction waste material. In 2004 the FHWA limited the definition of recycled concrete aggregate (RCA) to the byproduct of old Portland cement concrete pavements, bridge structures/decks, sidewalks, curbs, and gutters and that the steel is removed from the old concrete. The main reason for limiting the definition of RCA is that state projects typically use high-quality aggregate, and have consistent properties defined in state specifications. Figure 4 below provides the extent of use for recycled concrete aggregate (FHWA 2004).

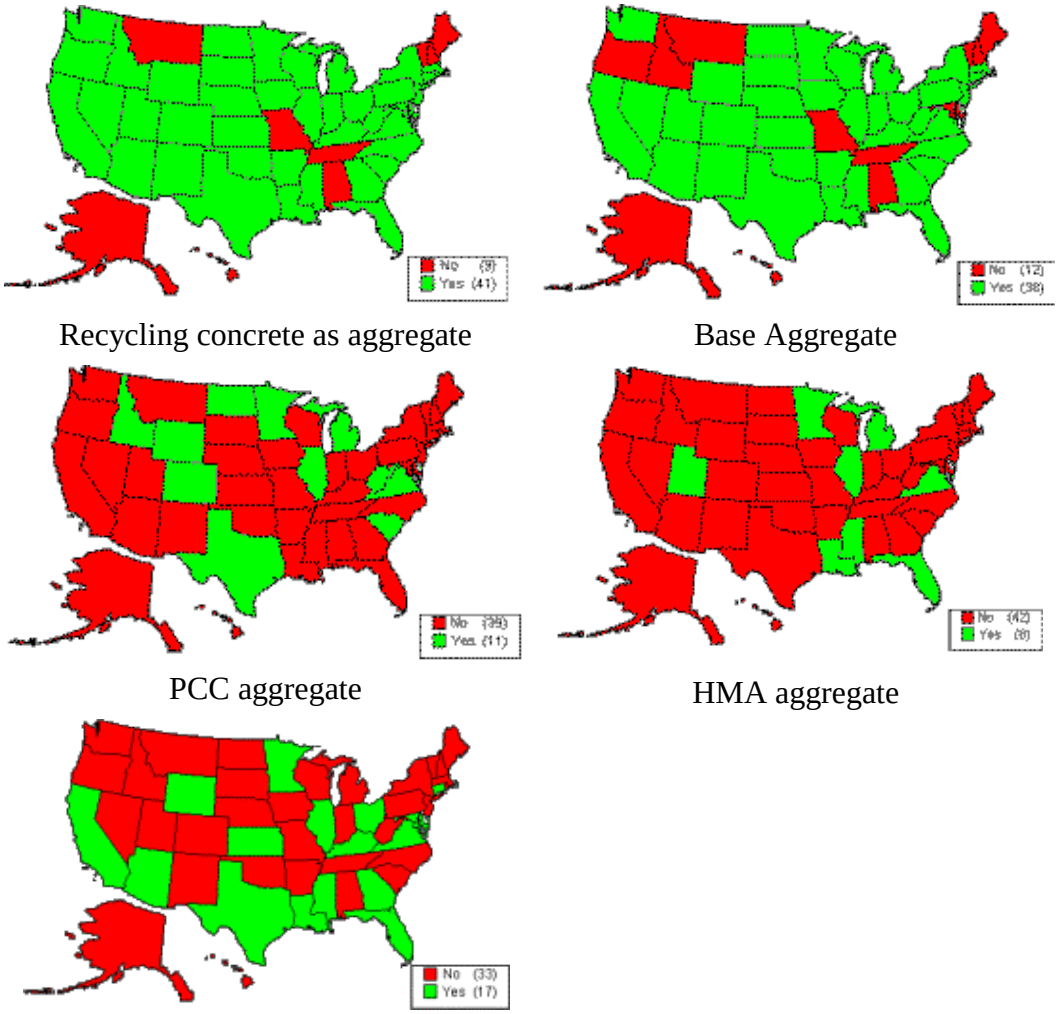

Figure 4: Approved uses for RCA in each state

(Gallican 2011)

The FDOT has sponsored research testing blends of RAP with crushed concrete for highway applications. Blends of 50% RAP/50% RCA and 25% RAP/75% RCA were tested for stabilized subgrade. The 50% RAP/50% RCA blend produced an LBR slightly above the specification for stabilized subgrade. The report suggested that 50%/50% blends would have to be evaluated to determine if they are suitable for stabilized subgrade. The blends of 25% RAP/75% RCA produced an unsoaked LBR of 76. This did not meet the requirement for base

course (100 LBR) but the report suggests that these blends may be suitable for subbase material (Cosentino 2012).

Current FDOT specifications allow for crushed concrete from existing concrete pavements to be recycled into new pavement as base or aggregate material. The specifications also permit crushed concrete from general construction and demolition waste if the source is approved by the FDOT (FDOT 2013 FAQ).

2.1.4 Recycled Tires

Tire waste is another reclaimable construction waste material. The NCHRP Synthesis 435 outlines many uses of recycled tires. It can be used as aggregate in Portland cement concrete (PCC), asphalt cement, and also as an embankment material. The report stated that when using crumb rubber in precast panels for PCC pavements, it improved thermal cycling resistance, lowered weight, lowered cost, and increased sound resistance by 36%. Pavement surface binders can be prepared with crumb rubber modified (CRM) mixes. These include chip or cape seals, rubber emulsion asphalt slurry, and crack sealing. The FDOT has approved the use of recycled tires in asphalt concrete friction courses and asphalt rubber membrane layers (Stroup-Gardiner and Wattenberg-Komas 2013).

In 1996, the FDOT published *Effect of Tire Rubber Grinding Method on Asphalt-Rubber Binder Characteristics*. This report examined the effects of different grinding processes on the properties of asphalt-rubber binder. The research found that wet-ground rubber material has lower bulk densities and larger surface areas. It also stated that ground tire rubber with greater specific surface areas and more irregular shaped particles produces higher viscosities. Binders

with cryogenically ground rubber had the greatest amount of settlement and least resistance to drain down (West et al., 1996).

In 2011, the Florida Department of Environmental Protection published *Waste Tires in Florida: State of the State*. This paper states that in 2010, 192,500 tons, or 19,250,000 passenger equivalent waste tires, were generated in the state of Florida. It also states that Florida is the only state that specifies modified rubber asphalt in the friction course of all state-maintained roads. However, polymers have been replacing the use of displaced crumb rubber in some road classes. Crumb rubber is not the only market for recycled tires, and the report states that in 2008, almost 92% of the 19.5 million waste tires generated in Florida were constructively utilized in diverse applications" (DEP 2011). Other applications for waste tires are fill material, energy generation, and artificial reef creation (FDEP 2011).

2.1.5 Crushed Glass

Crushed glass can also be used as an aggregate in in Portland cement concrete mixtures. In 2012, the United States Department of Transportation published *Utilizing Coal Fly Ash and Recycled Glass in Developing Green Concrete Materials*. The "Glasscrete" was found to have a lower compressive strength and inferior abrasion resistance than natural sand concrete. However, Glasscrete mixtures require less plasticizer, set slightly faster, and show a lower coefficient of thermal compression (Rajabipour et al. 2012).

The FHWA has published the report "User Guidelines for Waste and Byproduct Materials in Pavement Construction." This report suggests that hot mix asphalt pavements with 10-15% glass perform satisfactorily. Higher blends with up to 25% glass can potentially be used for base or binder courses. Hot mix asphalt surface courses with more that 15% glass may

deteriorate due to stripping of the asphalt cement binder from the glass. The FDOT has approved the use of up to 15% recycled crushed glass by total aggregate weight in asphalt mixtures, except in the final wear surface (FHWA 1997).

2.2 Survey of Current Practice

The research team contacted each state transportation department to obtain insight into their specific approaches to promoting the use of recycled and reuse materials. A survey was sent to each state DOT to inquire if the state has used mandates or offered incentives to use recycled materials in their contracts. Correspondence was initiated by either personal email to the State Highway Engineer or through the department's website inquiry page. Inquiries were sent to each of the 50 state DOTs, and 36 states responded. The survey, as well as the initial responses, can be found in Appendix A to this report. States which had either automated responses, contact referrals, no response, or innovative practices were contacted further by phone to gather more detailed information.

Survey results suggest there are four principal categories of initiatives that DOTs have used in promoting recycling construction waste:

- Permissive Technical Specifications
- Construction Contract Incentives
- Construction Contract Mandates
- Statutory Requirements

Permissive specifications are the most common form of promoting the use of recycled construction waste materials. Permissive specifications allow for the contractor to use his or her own judgment on how much recycled material is to be used on the project, up to a specified

maximum. This allows the market to dictate how much recycled material is used. Because RAP is cheaper than virgin materials it benefits the contractor to use as much as possible in their mixes to save money. Every state which responded has permissive specifications for certain types of recycled construction waste. For example, the FDOT permits the use of up to 20% of RAP in mixes with polymer modified asphalt binders. [1]

There are other states which allow higher percentages of RAP in their mixes. Nebraska indicated that they have been extremely successful with their RAP usage and believe they may use the most RAP of any state. Nebraska averages 37% RAP in their mixes and have approved up to 50% in all lifts. They believe that their success has come from giving the contractors full ownership of all RAP millings. The example provided was in a two inch reclamation the top inch of material would be milled, and then the RAP created would be used as half of the new design mix aggregate.

Incentives have been used by various transportation departments to help alleviate stockpiles of materials which have become burdensome. Three states have offered incentives in their contracts for the use of recycled materials. In the late 1980's through the early 1990's the New Jersey Department of Environmental Protection (NJDEP) was looking to help the container glass recycling industry with their waste stream. Therefore, the NJDEP contributed $1/ton of asphalt which contained recycled container glass. New York initiated a similar campaign to reduce stockpiling of waste tires. State legislators passed a law providing funding to place tire

[1] For specific specifications on FDOT treatment of RAP see the FDOT January 2015 Standard Specifications http://www.dot.state.fl.us/specificationsoffice/Implemented/SpecBooks/default.shtm

derived aggregate in lieu of soil for embankments. It was stated that they were successful in this project and that the waste tire stockpiles were remediated ahead of schedule. Texas also previously had an incentive for using recycled materials. Contractors which used recycled materials had a 4% retainer opposed to the normal 5%. However, the state of Texas no longer requires a retainer on construction projects.

Mandates are another way in which transportation departments have promoted the use of recycled materials. Of the responding states, 14 stated that they have required the use of recycled materials on their project. The origin of many of these mandates was a research project by the DOT to better understand the performance properties of the materials. Mandated materials have included recycled tires, fly ash, and asphalt millings. The mandates specified either in the specifications of the project or in construction notes on the plans.

Legislation is another solution that at least one state has used to help the distribution of recycled construction waste materials throughout. In Texas the State is required to give each county $6 million worth of material per year for construction. It was stated that much of this material requirement is fulfilled by RAP. This gives counties the decision on what to do with their own RAP as they see fit. This legislation is a rider in an Appropriations Bill of Texas.

Table 2 provides the results of the project survey and indicates the ways each DOT has promoted the use of Recycled materials in their contracts. Appendix A contains complete documentation of the response received from each DOT. Appendix B provides specific examples of specification language and plan notes furnish to the research team by the DOT respondents.

Table 2: Summary of Approaches Used by States to Promote the Use of Recycled Materials in Their Construction Programs

State	Permissive Specs	Incentives	Mandates	Legislation
GA	X			
AL	X			
SC	X			
NC	X			
VA	X			
WV	X			
MD	X			
DE	X		X	
NJ	X	X	X	
RI	X			
CT	X		X	
MA	X			
ME	X			
NH	X			
VT	X			
NY	X	X	X	
PA	X			
OH	X			
KY	X			
TN	X			
MI	X		X	
IN	X			
MS	X			
WI	X			
IL	X		X	
LA	X			
AR	X			
MO	X			
IA	X			
MN	X		X	
TX	X	X	X	X
OK	X			
KS	X		X	
NE	X			
SD	X		X	
ND	X		X	
MT	X			
WY	X		X	

Table 2, continued

State	Permissive Specs	Incentives	Mandates	Legislation
CO	X		X	
NM	X			
ID	X			
UT	X			
AZ	X			
WA	X			
OR	X			
CA	X		X	
AK	X			
HI	X			
NV	X			

2.3 Summary of Literature Review and Current Practice

The majority of research efforts appear to have focused on technical materials engineering issues associated with using recycled waste materials as a component in conventional construction materials such as asphalt pavement or Portland cement concrete. It appears that most state DOTs have implemented permissive material specifications, which permit the inclusion of varying percentages of recycled materials into new mixes. There are a few examples of the implementation of incentives and mandatory requirements. Additionally, there are examples of statutory recycling requirements. The next section of this report presents an engineering characterization the materials which are reusable from FDOT construction waste.

3. Physical Properties of Reclaimed Materials

3.1 Introduction

This section of the report provides a characterization of the physical properties of recyclable construction material generated by the FDOT work program. This information is a necessary prerequisite to developing reuse and recycling strategies. Appropriate material property characteristics were determined based upon the current FDOT Standard Specifications and other published research documents. An estimate of the quantity of potentially recyclable and reusable materials generated from the FDOT work program was developed. Additionally a preliminary analysis of the economic factors influencing the business operational considerations was developed.

3.2 Recycled Asphalt Pavement (RAP)

The FHWA describes the physical characteristics of RAP in the "User Guidelines for Waste and Byproduct Materials in Pavement Construction." The constituent materials and the type of asphalt concrete mix have a major effect on the physical properties of RAP. Aggregate in the surface course generally has higher resistance to abrasion and wear to perform to the given specifications. Because of this aggregates in the friction course may be of higher quality than those found in binder courses where abrasion resistance is not of concern (FHWA 2012).

Milling and crushing can cause aggregate degradation. This causes the gradation of RAP to be typically finer and denser than virgin aggregate. Crushing does not degrade the material as much as milling, making the gradation of crushed RAP generally not as fine as milled RAP, but finer than virgin material crushed with the same equipment (FHWA 2012).

Most RAP is crushed or milled to 1.5 inches or less, with a maximum allowable top size of either 2 or 2.5 inches. Table 3 presents the typical range of particle size distribution for crushed or milled RAP. Table 4 presents the typical mechanical and physical properties of RAP.

There are two recent research reports published by the FDOT concerning the physical properties of RAP: "Evaluation of Use of High Percentage of Reclaimed Asphalt Pavement (RAP) for Superpave Mixtures" (FDOT 2007) and "Laboratory Evaluation of Polymer Modified Asphalt Mixture with Reclaimed Asphalt Pavement (RAP)" (FDOT 2009) both analyze rutting and cracking resistance for various RAP mixes. The 2007 FDOT report analyzed Superpave mixes with varying amounts of rap. The testing evaluated rutting and cracking performance of mixes containing 0%, 25%, 35%, and 45% RAP contents. (Kim et al. 2007)

An Asphalt Pavement Analyzer (APA) test was performed on the various mixes to determine rutting performance. The control mixture (0%) demonstrated better performance than the 25% RAP mixture, but the report found no significant difference between the control, 35% RAP, and 45% RAP. Figure 5 presents the results of this test. (Kim et al. 2007).

A Servopac gyratory shear test was also performed on the mixtures. This test showed a reasonable trend with regard to rutting performance of the four mixes in terms of vertical strain. The results of this test can be seen in Figure 6 (FDOT 2007). The Superpave indirect tension test (Superpave IDT) was performed on the mixtures to evaluate their resistance to cracking. This test quantifies the resilient modulus, creep, tensile strength, fracture energy, and dissipated creep strain energy (DCSE). Using these quantities ultimately allows for the calculation of the energy ratio of the mix which is a ratio of the DCSE threshold of the material and the minimum DSCE needed.

The tensile strength decreased as the RAP content of the mix increased. The tensile strength test results can be seen in Figure 7.

Table 3: Typical Range of Particle Size Distribution for RAP (Percent by Weight Passing, FHWA, 2012)

Typical RAP Gradation	
Screen Size (mesh)	**Percent Finer After Processing or Milling**
37.5 mm (1.5 in)	100
25 mm (1.0 in)	95 - 100
19 mm (3/4 in)	84 - 100
12.5 mm (1/2 in)	70 - 100
9.5 mm (3/8 in)	58 - 95
75 mm (No. 4)	38 - 75
2.36 mm (No. 8)	25 - 60
1.18 mm (No. 16)	17 - 40
0.60 mm (No. 30)	10 - 35[a]
0.30 mm (No. 50)	5 - 25[b]
0.15 mm (No. 100)	3 - 20[c]
0.075 mm (No. 200)	2 - 15[d]
a. Usually less than 30 percent b. Usually less than 20 percent c. Usually less than 15 percent d. Usually less than 10 percent	

Table 4: Physical and Mechanical Properties of RAP (FHWA, 2012)

Typical Properties of RAP		
Type of Property	**RAP Property**	**Typical Range of Values**
Physical Properties	Unit Weight	1940 - 2300 kg/m^3 (120-140 lb/ft$^{3)}$
	Moisture Content	Normal: up to 5% Maximum: 7-8%
	Asphalt Content	Normal: 4.5-6% Maximum Range: 3-7%
	Asphalt Penetration	Normal: 10-80 at 25°C (77°F)
	Absolute Viscosity or Recovered Asphalt Cement	Normal: 4,000 - 25,000 poises at 60°C (140°F)
Mechanical Properties	Compacted Unit Weight	1600 - 2000 kg/m^3 (100-125 lb/ft^3)
	California Bearing Ratio (CBR)	100% RAP: 20-25% 40% RAP and 60% Natural Aggregate: 150% or higher

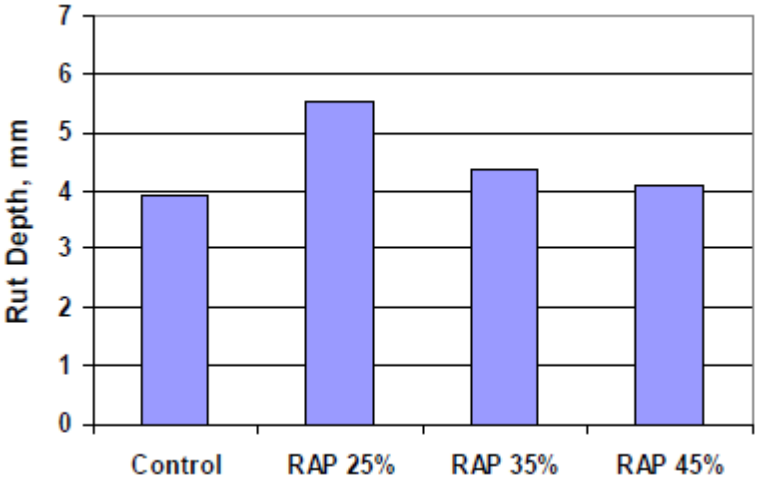

Figure 5: APA test result for varying RAP mixes

(Kim et al. 2007)

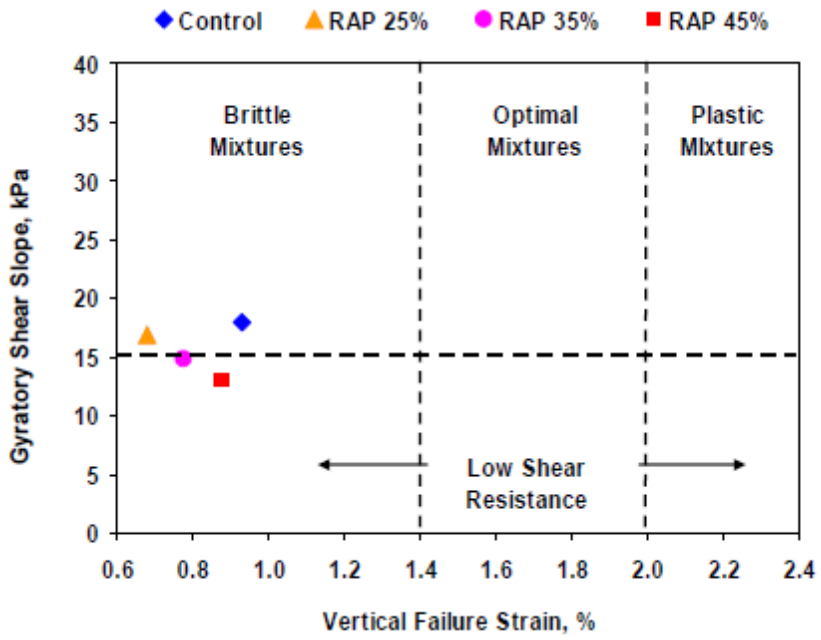

Figure 6: Servopac gyratory shear test results for varying RAP mixes (Kim et al. 2007)

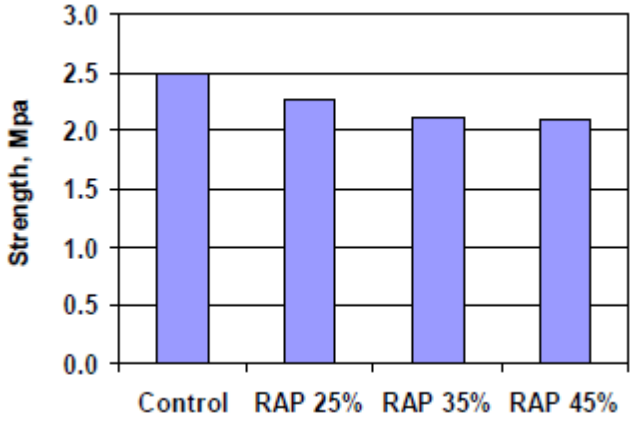

Figure 7: Tensile strength test results for varying RAP mixes (Kim et al. 2007)

The fracture energy (FE) also decreased as the amount of RAP increased. The FE for the 45% RAP mixture had the same binder as the 35% RAP mixture, but demonstrated a lower FE. The report suggested that this is the result of using more RAP with the same binder. To compare this, the FE for the 35% mixture was only slightly lower than the 25% mixture. It was stated that since the 35% mixture uses a softer binder than the 25% mixture, it compensated for the added RAP content (FDOT 2007). The FE results can be seen in Figure 8.

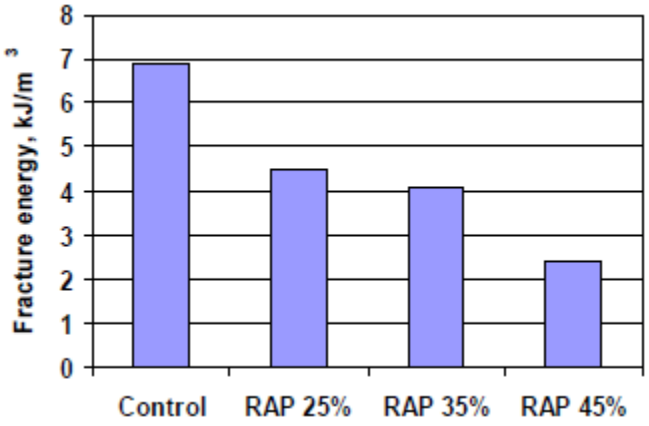

Figure 8: Fracture energy results for varying RAP mixes
(Kim et al. 2007)

The creep compliance results are slightly more complex. The control mixture had a higher compliance rate than the 25% RAP, even though the 25% RAP mixture had a softer binder. The 35% RAP had the highest creep compliance of all the other mixtures. This was due to the 35% mixture using a softer binder than both the 25% mixture and control. The 45% RAP mixture had a reduced rate of creep compliance compared to the 35% since it contained more RAP and the same binder. This result correlates with the APA test results. The results from this test can be seen in Figures 9 and 10.

The energy ratio results show that higher percentages of RAP may decrease cracking resistance. The results of the energy ratio can be seen in Figure 11. In 2001, the FDOT published the report for *Developing Specifications for Using Recycled Asphalt Pavement as Base, Subbase, or General Fill Material*. This project examined the engineering properties of RAP for base, subbase, and fill uses. This project tested if different milling and compaction methods will satisfy the FDOT LBR requirement for base (LBR of 100), and subbase, (LBR of 40). Figures 12 and 13 present the relationship of moisture content, compaction method, and LBR for the two milling methods (Cosentino and Kalajian 2001).

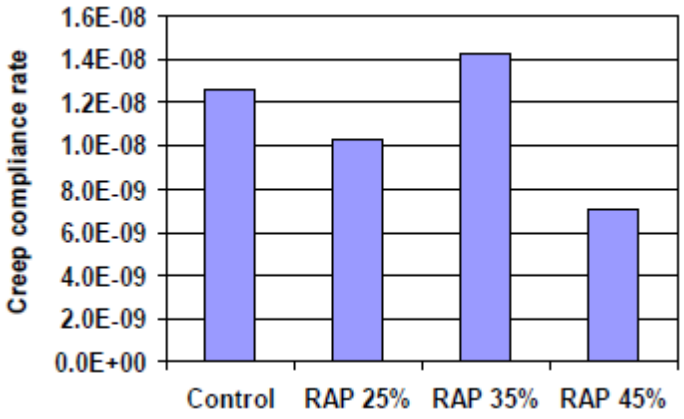

Figure 9: Creep compliance rate for varying RAP mixes (Kim et al. 2007)

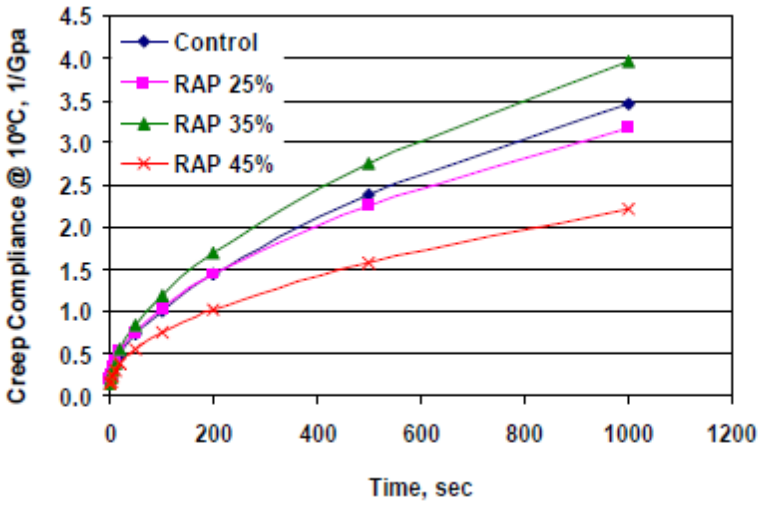

Figure 10: Creep compliance rate for varying RAP mixes

(Kim et al. 2007)

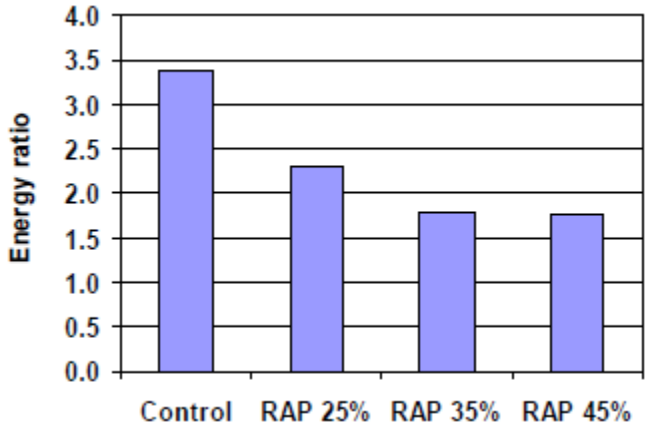

Figure 11: Energy ratio results for varying RAP mixes

(Kim et al. 2007)

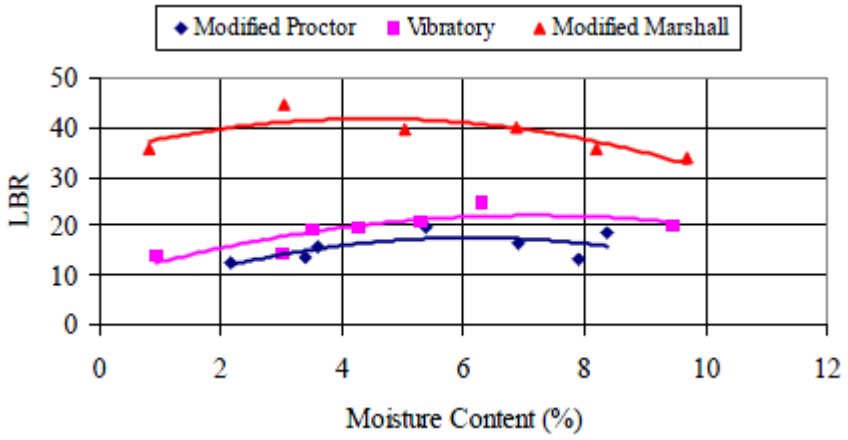

Figure 12: Moisture content LBR relationship for hammermill RAP (Cosentino and Kalajian 2001)

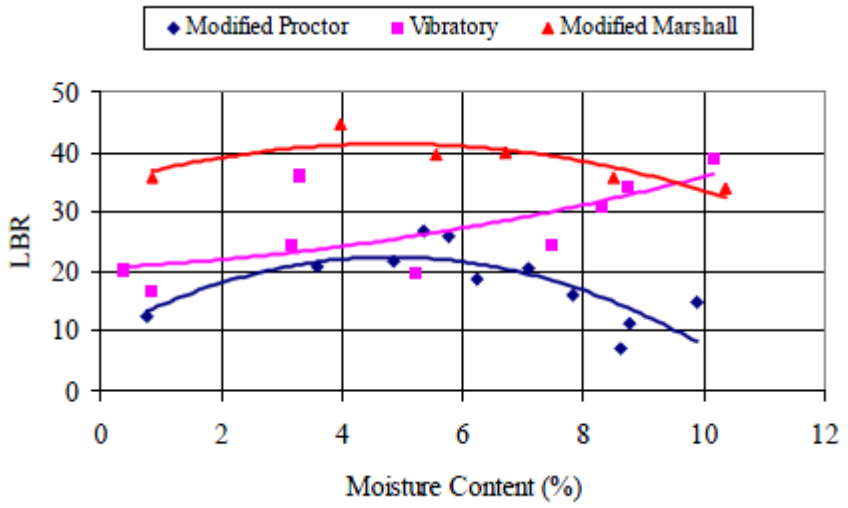

Figure 13: Moisture content LBR relationship for tubgrinder RAP (Cosentino and Kalajian 2001)

3.2.1 Tentatively Suggested Reuse Opportunities

RAP is commonly used as a component of hot mix asphalt pavements. Additionally, laboratory tests from Cosentino and Kalajian (2001) suggested that RAP may be suitable for base, subbase, and fill material. In field tests the subbase was able to sustain an LBR value over 40 in 80% of the tests, but RAP used as base course could not maintain an LBR over 100 during warm months. This led to the conclusion that RAP is suitable for subbase, but not feasible as pavement base course material due to low LBR values.

3.3 Recycled Concrete Aggregate (RCA)

Tables 5 and 6 present typical values for the physical properties of crushed concrete provided by the FHWA. In 2001 the FDOT funded a research study to analyze the use of RCA made with Florida limestone aggregate for base course in flexible pavements. This study tested the performance of Florida RCA. The following figures present the results with regard to gradation, LBR, LA abrasion loss from lab testing (Kuo et al. 2001).

The gradation testing determined that most samples collected throughout the state met the gradation requirements established by FDOT Specification Section 204, except for Districts 5 and 6. These two districts did not have acceptable gradations due to large amounts of anomalies and foreign material found in the RCA. Gradation test results are given in Figure 14 (Kuo et al. 2001). The LBR test results are given in Figure 15 (Kuo et al. 2001). The LBR was calculated for each district to determine the stability of RCA. The arithmetic mean of the LBR values is greater than the 100 LBR value required by the FDOT for base material, and the report suggests that well processed RCA is an acceptable material for base course in pavement construction.

An LA abrasion loss test found that RCA has an abrasion loss greater than natural aggregate. The test produced a range of values from 41.1% to 47.6%, but the average was less than the FDOT specified 45%. Figure 16 presents the results of LA abrasion testing of RCA.

Table 5: Typical Physical Properties of Processed Reclaimed Concrete Material (FHWA, 2012)

Typical Properties of Crushed Concrete	
Property	**Value**
Specific Gravity	
- Coarse particles	2.2 to 2.5
- Fine particles	2.0 to 2.3
Absorption, %	
- Coarse particles	2 to 6
- Fine particles	4 to 8[(a)]
(a) Absorption values as high as 11.8 percent have been reported.	
Los Angeles Abrasion Loss (ASTM C131), (%)	
- Coarse particles	20-45
Magnesium Sulfate Soundness Loss ASTM C88), (%)	
- Coarse particles	4 or less
- Fine particles	less than 9
California Bearing Ratio (CBR), (%)*	94 to 148
* Typical CBR value for crushed limestone is 100 percent.	

Table 6: Six-year Study of RCA from Uncontrolled Stockpiles on Long Island, NY (FHWA, 2012)

Physical Property	Test Results		
	Mean	**Std. Dev.**	**Tests Performed**
Magnesium Sulfate Soundness (%)	3.8	1.3	107
Los Angeles Abrasion (%)	36.5	3.6	112
Dry Density (lb/ft$^{2)}$)	129	2.6	143
CBR (%)	148	28.7	157

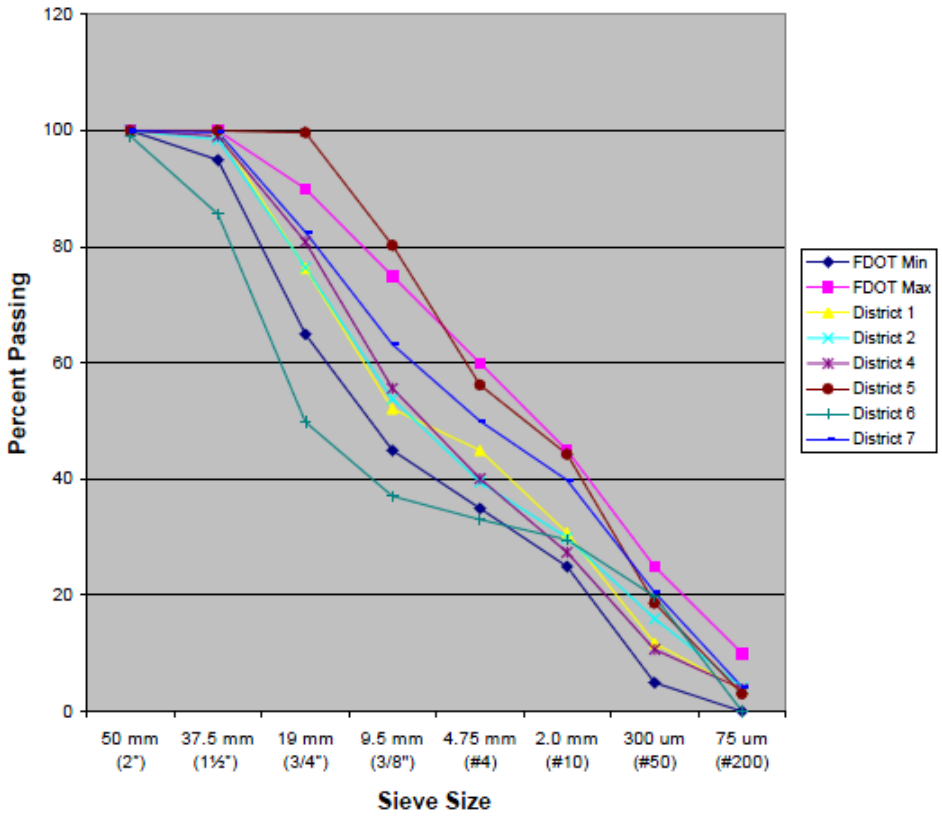

Figure 14: Gradation of Florida RCA by district

(Kuo et al. 2001)

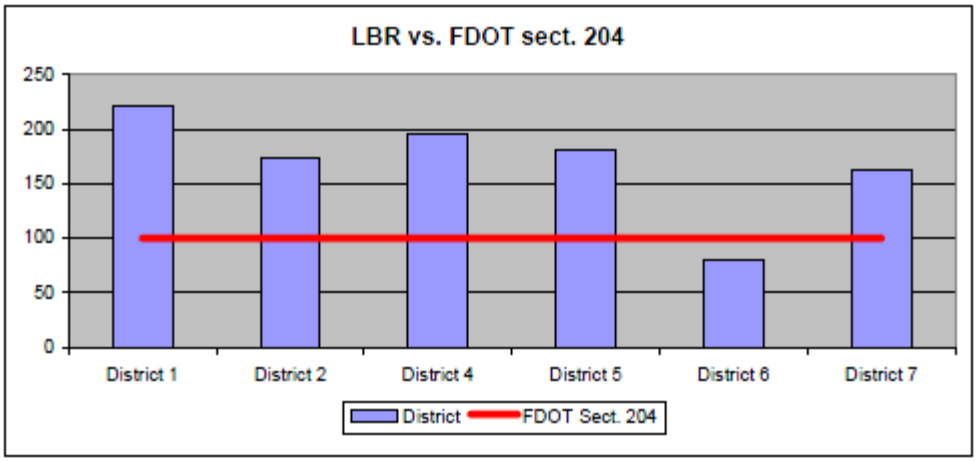

Figure 15: Average RCA limerock bearing ratio

(Kuo at al. 2001)

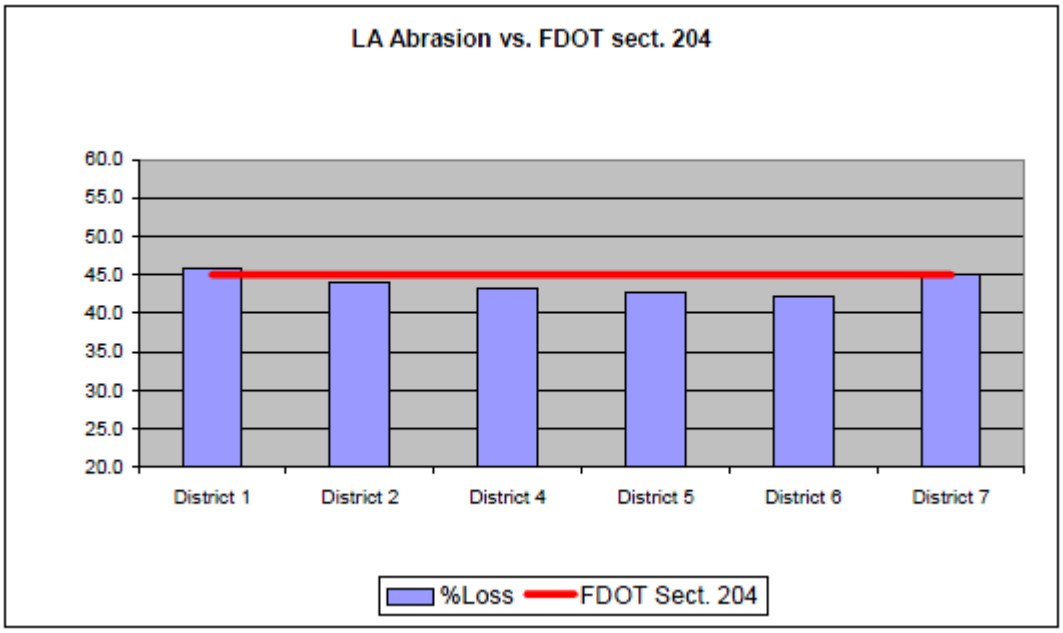

Figure 16: Average RCA LA abrasion loss compared to FDOT Specifications 204 for natural aggregates

(Kuo et al. 2001)

3.3.1 Tentatively Suggested Reuse Opportunities

Previous research has demonstrated the acceptable use of RCA in non-structural strength concrete mixes (Lim 2003).

Additionally, the findings in (Kuo et al. 2001) suggest that RCA can be effectively used as base course material with proper quality control. The report lists six recommendations for the selection and processing of RCA for proper quality control. These recommendations are as follows (Kuo et al. 2001):

- Before processing the contractor must carefully select the demolished building or other structure and plan to have a separate storage area for the rubbles.
- Reinforcing steel must be removed by using an overhead magnetic separator, then impact mills can be used to crush the rubble into various sizes, and finally air classifiers should be used to remove lightweight debris such as wood and plastic.
- The RCA should be washed before using. Washing is also required to remove the dust as a measure of reducing potential tufa (porous limestone formed from calcium carbonate) formation. Additional quality control testing may be necessary to estimate the tufa precipitate (leachate) potential of RCA aggregates for embankment applications.
- The material must possess comparable compressive and shear strengths of natural aggregate, meet gradation of particle size distribution, and provide proper workability.
- RCA must not contain harmful impurities such as lead and asbestos, and it must not react with either cement or reinforcement when it is used for concrete add mixtures.

- The output quality must be guaranteed by systematic and rigorous monitoring, as well as intensive sampling and testing of the material characteristics (including environmental properties). The basic requirement for producing high quality recycled aggregate is the selection of the material entering the preparation process; this presumes a well-organized acceptance and storage of the incoming material as well as effective material management.

3.4 Recycled Tires

The physical properties of recycled rubber depend on the configuration of reclaimed rubber being used. The types of rubber defined by the FHWA are shredded tires, tire chips, ground rubber, and crumb rubber (FHWA 2012).

Shredded tires are relatively flat, irregularly shaped tire pieces with jagged edges that may or may not have sharp pieces of metal protruding from them. The size of tire shreds can range from 1”-18”, with most particles in the 4”-8” range. The average loose density of tire shreds varies depending on the size of the individual shreds, but typically ranges from 24 lb/ft^3 to 33 lb/ft^3. The average compacted density ranges from 40 lb/ft^3 to 52 lb/ft^3 (FHWA 2012).

Tire chips are finer and more uniform than tire shreds. Their size ranges from 1/5”-3”. The size varies with the make of the tire and processing equipment. The loose density of tire chips is typically between 20 lb/ft^3 to 30 lb/ft^3, and the compacted density ranges from 35 lb/ft^3 to 45 lb/ft^3. The absorption value for tire chips ranges from 2.0% to 3.8% (FHWA 2012).

Ground rubber has particles which are intermediate in size between tire chips and crumb rubber with sizing ranging from 3/8 inch to No. 20 sieve (FHWA 2012).

Crumb rubber which is used in hot mix asphalt generally has 100% of the particles passing the No. 4 sieve. The majority of crumb rubber particles are sized within the No. 16 sieve to No. 40 sieve, though some particles may be as fine as No. 200 sieve. The specific gravity of crumb rubber is approximately 1.15. Crumb rubber must be free of all fabric, wire, and other contaminants (FHWA 2012).

3.5 Crushed Glass

Crushed glass particles are generally angular in shape and can contain some flat or elongated particles. The amount of processing affects the degree of angularity. Extra crushing will create smaller particles with somewhat less angularity and reduced amounts of flat and elongated particles. Proper crushing methods can help eliminate sharp edges and corresponding safety hazards associated with the handling of the product (FHWA 2012).

Uncontaminated glass exhibits consistent properties, but waste glass has more variable properties due to the presence of non-glass debris. Table 7 presents typical properties of crushed glass.

Table 7: Selected Physical Properties of Waste Glass (FHWA, 1997)

Test	**Glass Samples**		**ASTM Test Method**
	Coarse	**Fine**	
Particle Shape			ASTM D2488
Angularity	Angular	Angular	
Flat (%)	20-30	1	
Flat/Elongated (%)	1-2	1	
Specific Gravity	1.96 - 2.41	2.49 - 2.52	ASTM D854 ASTM C127
Permeability (cm/sec)	~2 x 10^{-1}	~ 6 x 10^{-2}	ASTM D2434

3.6 Preliminary Estimate of the Quantity of Reusable Materials from the FDOT Construction Program

3.6.1 Required Diversion from Landfills

In 2008, the Florida Legislature passed House Bill 7135 which established a recycling goal of 75% by the year 2020 (FDEP 2013). In 2009, 6.72 million tons of construction and demolition waste was generated in the state of Florida. Figure 17 provided by Sullivan and Ketchey (2011), presents the construction and demolition waste generated in 1998 in Florida by material type. Concrete and asphalt accounted for 91% of the construction and demolition waste generated. The remaining materials are wood and miscellaneous items.

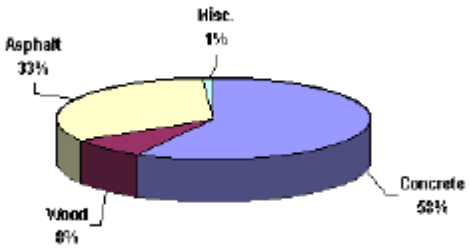

Figure 17: C&D waste generated in Florida in 1998
(Sullivan and Ketchey 2011)

3.6.2 Crushed Concrete (RCA) and Recycled Asphalt Pavement (RAP) Estimated Quantities

An estimate of the quantity of waste concrete generated from the FDOT construction program was developed using the FDOT's historical cost information. The FDOT historical cost data includes the total quantity for each bid item. Bid item quantities from the calendar year 2012 were used to estimate the generated waste materials. Item number "0327 70 X Milling Existing Asphalt Pavement, SY" was used to estimate the RAP quantity. Based upon the quantities for

this item, the total estimated quantity of RAP produced in 2012 was estimated to be 1,790,758 Tons.

Two items were used to estimate the total amount of waste concrete generated from the FDOT construction operations: Item “0110 3 Removal of Existing Structure, SF” and Item 0110 4 “Removal of Existing Concrete Pavement, SY”. With regard to the concrete pavement removal, an average pavement depth of 9 inches was assumed. An analysis of a typical existing bridge removal resulted in a conversion factor of 0.11 CY per SF of structure. The total estimated quantity of waste concrete produced in 2012 was estimated to be 94,175 Tons. Details of the calculations of the RAP and RCA quantities are included in Appendix D. It is reasonable to believe that FDOT waste production in future years would be proportional to the work program cost amount.

3.6.3 Preliminary Cost Models

In 2008, The Hinkley Center for Solid and Hazardous Waste Management published “Cost Model for Diverting Construction and Demolition Waste in North Central Florida.” This paper outlines the state of construction and demolition waste recycling in the state of Florida (Sullivan and Ketchey 2011). It states that in 2007, 6.8 million tons of construction and demolition waste were sent to Florida landfills, and that the goal for Florida is to reach 75% recycling of Municipality Solid Waste by 2020. This report created models comparing the costs incurred for sending waste C&D material to a landfill vs. diverting it. The Hinkley cost models were used to estimate the savings incurred from diverting the materials generated by the FDOT work program. The full cost models are provided in Appendix E. However, the Hinkley model basically only addresses the savings resulting from avoiding landfill disposal costs.

3.6.4 Crushed Concrete RCA

Concrete has a reported savings of $134/ton by diverting from the landfills. With an estimated 94,175 tons of waste concrete being produced in 2012 from FDOT construction, there is an estimated savings of $12,431,100 resulting from diverting all of the concrete waste from landfills. Again it should be said that this does not take into account the value of recycling and/or reusing the material.

From the perspective of the recycling production facility, the following general cost model is indicative of the relationships influencing business profitability.

$$P = pn – (F + cn)$$

Where:

P = profit

p = sales price per unit

F = fixed operating cost per time period

c = manufacturing cost per unit

n = quantity produced per time period

At the break-even point, P = 0. The break-even sales volume is a function of the operating cost variables.

3.6.5 RAP

Although FDOT specifications allow for up to 30% RAP in some cases in Florida, this is rarely the case. The average, current estimated mix designs according to industry professionals is around 15%. At this rate it is not possible to reuse the entire RAP generated by the state in new asphalt mixes. However, RAP has been approved for embankment fill material. Given the

quantity of Embankment required in the FDOT work program it would be possible to reuse all generate RAP in embankment fill. The reality is that there are operational issues to be considered. RAP is typically not transported to landfills. Rather it winds up generally in storage at the contractor's facilities, usually an asphalt batching plant.

The same general cost model presented under the previous concrete discussion is also applicable to RAP materials. However, the cost factors are different. RAP is milled by the contractor and then transported to a holding yard (generally an asphalt plant) where it is then used in various mixes. Often the contractor owns the asphalt plant where the RAP is being stored therefore, the costs for RAP operations are associated with the transportation and warehousing of the material.

3.6.6 Other Materials

Opportunities for the use of recycled materials in lieu of virgin materials will be further examined in the next section of this report to include input from industry professionals. The economic viability of currently available recycled materials will be discussed with industry professionals.

3.7 Summary

The engineering material properties of common waste materials from transportation construction programs have been extensively researched. The typical engineering material properties are reported in this section of the report within the context of a transportation construction program. Knowledge of the material properties is a necessary prerequisite to exploring reuse and recycle opportunities.

Beginning in 2020 it will be necessary for 75% of the waste generated by the FDOT work program to be diverted from the landfill. Crushed concrete RCA and RAP contribute to a large portion of the waste produced. Reclaiming the majority of this material within the FDOT area that it is generated, a large portion of the 75% goal can be achieved. The following section of this report focuses on obtaining input from experienced professionals concerning the current state of recycling and reuse in Florida.

4. Structured Interviews with Experienced Industry Professionals

4.1 Introduction

This section of the report provides a summary of the information obtained from interviews with experienced industry professionals directly involved in the recycling of construction waste materials. Representatives from major aggregate recycling firms, HMA producers, Portland cement concrete producers, and FDOT contractors were contacted. Telephone conference call and face-to-face interviews were conducted using a structured format to improve the completeness of the information obtained. A synthesis of the information is included in this report and provides a better understanding of factors influencing the reuse and recycling of materials related to construction and more specifically the FDOT work program.

4.2 Industry Interviews

Interviews were conducted with representatives of each the following organizations. Note that the information obtained is summarized in this report. However, specific comments attributable to specific individuals have not been reported as a courtesy to the interviewees.

4.2.1 Industry Profiles of Participants

Independence Recycling

Contact: Greg Moro, Florida Operations Manager/Punta Gorda Sales

Independence recycling has a number of operating facilities throughout the southeast United States. They handle RAP, crushed concrete, sand, and rip-rap. Their Orlando office (the most productive office) produced 165,000 tons last year. Other yards produce between 70,000 and 80,000 tons per year. Independence primarily gets their material from private demolition

projects. About 15% of their material comes from FDOT projects. Independence's materials are mainly used for road base, subbase, material under brick pavers, nonstructural concrete, and concrete block. http://www.indrec.com/

Crush-It, Inc.

Contact: John Wohlwend, Chief Financial Officer

Crush-It recycles 60% asphalt and 40% concrete. Viable plant operating minimum require 1,000 tons/day concrete or 2,000 tons/day of asphalt. Their concrete product is mostly being used by private construction and road base. Their asphalt RAP is being used for FDOT projects as well as private projects for road base or sold to asphalt batch plants. Some of their RAP material is being sold to counties. http://www.crushitinc.com/

Figure 18: Crush-It portable concrete crusher

Transcor Recycling

Contact: Candice Agosto, Aggregate Division Manager

Located in Tampa, Transcor recycles asphalt, concrete, as well as all other construction waste. Their RAP material is mostly sold to asphalt plants and for use for parking lots. Their crushed concrete is used mainly for road base. http://www.kccscraprock.com/default.asp

Figure 19: Recycled aggregate stockpile at Transcor Recycling[2]

Anderson Columbia Co., Inc.

Contact: Carl Dempsey, Materials Quality Manager

[2] (http://www.kccscraprock.com/index.asp?content=Facilities&contentTitle=Facilities)

Anderson Columbia operates throughout the complete material supply chain including mining aggregates, producing both Portland cement concrete and HMAC, and as a transportation construction contractor. This breath of experience gives them a unique insight into the subject of recycling on FDOT projects. http://www.andersoncolumbia.com/

Figure 20: Anderson Columbia RAP stockpile at their Lake City plant

Strategic Materials

Contact: Tim Miller, Plant Manager

Strategic materials receive most of the curbside pickup recycled glass in the state of Florida as well as some from South Georgia. Their Florida plant is located in Sarasota, Florida. Strategic Materials crushes and cleans the glass to sell to industry customers. The furnace industry is their primary customer for recycled glass which is supplied as cullet.

Figure 21: Crushed glass stockpile at Strategic Materials[3]

Waste Management Inc.

Contact: Shiraz Kashar, Community Outreach Manager

Waste Management Inc. is the largest waste management company in the United States. The scope of their operations includes curb side pickup of waste and recycling, recycling distribution and landfill operations. https://www.wm.com/about/index.jsp

Florida Concrete Recycling

Contact: Scott Renfroe, Operations Manager

Florida Concrete Recycling is located in Archer and in Gainesville, Florida. Their Gainesville plant is located adjacent to the Argos Concrete batching plant. Last year they processed approximately 260,000 cubic yards of concrete. Most of the crushed concrete product is used for parking lots and concrete pavers. http://floridaconcreterecycling.com/

[3] (http://www.strategicmaterials.com/index.php/divisions/smi-glass/what-we-take-3mix-single-stream-mrf-glass)

Figure 22: Concrete being crushed at Florida Concrete Recycling facility in Gainesville, FL

Figure 23: Crushed concrete at Florida Concrete Recycling facility in Gainesville, FL

Titan America

Contract: Yvon Gaudin, Branch Manager Tampa Plant

Titan America is a heavy building materials company located in the Eastern United States. They mine aggregates and also produce ready mix concrete and related concrete products. http://www.titanamerica.com/

Argos USA

Contact:Matt Carabaca, Manufacturing Executive, Gainesville Operations

Argos USA is a is a subsidiary of Cementos Argos S.A., a multi-regional firm with headquarters in Colombia, S.A. Argos produces cement and concrete products including ready mix concrete supplied from various batch plant locations. http://www.argos-us.com/About-Argos/

SP Recycling Co.

Contact: Charlie Hobson, SP Recycling, Gainesville Operations

SP Recycling is a subsidiary of SP Recycling Southeast, LLC., a multi-regional firm with headquarters in Dublin, GA. SP operates recycling centers throughout the Southeast with several centers in Florida. They operate, under contract, the Alachua County Recovered Materials Processing (RMPF) facility located at the Leveda Brown Environmental Park and Transfer Station, Gainesville, Florida. The RMPF deals primarily with curb-side recycling products. http://sprecycling.com/

4.3 Results of Industry Interviews: What we have learned

The following preliminary findings are based upon a synthesis of the research team's discussions with industry.

4.3.1 Recycled Concrete

- A portion (but not all) of the waste concrete from FDOT and other construction projects is being delivered to recycling facilities. Some is sent to landfills and some winds up stock piled or dumped on private property.
- **The industry market demand for recycled concrete exceeds the currently available supply.** Recyclers reported that the limiting factor for their operations was the available supply of concrete to be recycled.
- **Recyclers receive waste concrete with no tipping fee or only a small fee.** The related pricing factors are: the location and the character of the concrete waste (amount of steel reinforcing).[4]
- The most common uses for crushed concrete are bedding stone, pavement or paver base materials, and parking area surfacing.
- **Use of crushed concrete for aggregate in concrete batching was an occasional and uncommon occurrence.** Most reported uses involved a customer request relating to a LEED certified project goal. Reported limiting factors:

  a) Concrete producers' preference for their own mined materials[5]

[4] It should be noted that reinforcing steel is removed from the crushed concrete and is recycled; however, the value of the steel does not offset the cost of removal.

b) Inconsistent supply of crushed concrete aggregate

c) Inconsistent market demand for ready mix containing recycled concrete

- Most of the recyclers mistakenly believed that only concrete salvaged from a FDOT project can be reused as concrete aggregate on a FDOT project.
- Recyclers are reluctant to produce, stockpile and perform quality testing of crushed concrete aggregates for FDOT use because there is not a consistent market demand for the material.

4.3.2 Recycled Glass

- Essentially all of the curb side and industry contributed recycling glass is being recycled.
- Currently the primary use (95%) is as glass cullet supplied to the furnace industry.
- Ground glass has a relatively high economic value (over $100 per ton). However, there are significant shipping costs to move the raw material from collection point to processing facilities, for example from Gainesville, Florida to Sarasota, Florida. Consequently, recycled glass remains a net loss for municipal recycling programs.
- Local processing of glass to include the production of fine aggregate materials would appear to be economically feasible because of the reduction in shipping cost.

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[5] The cost for crushed concrete aggregate was reported to be in the range of $25 per ton which would appear to be comparable to mined aggregate.

- Ground glass has been tried successfully as a fine aggregate component in concrete and HMAC mixes.[6]

4.3.3 Recycled Asphalt Pavement (RAP)

- The amount of RAP generated from roadway resurfacing operations currently significantly exceeds the amount of RAP being recycled in new HMAC mixes.
- Only a relatively small portion of the total RAP generated can be used in some instances: in new asphalt pavement, for shoulder base except on limited access roadways, and used on shared use paths.
- Current stockpiles of RAP materials are large and are growing rapidly.[7]
- Some Florida counties have considered using RAP as a surfacing material for low volume, previously unpaved roads.[8]

4.4 Tentatively Identified Barriers to Improving Recycling and Reuse of Materials in FDOT Projects

Analysis of the information provided by industry experts indicates the existence of the following barriers:

- A significant amount of demolition concrete is not being recycled

[6] Tire punctures have been reported and as a result glass is generally not permitted in the friction surface courses.

[7] See the photo provided in Figure 3 of the RAP stockpile at the Anderson Columbia plant, which is typical.

[8] Reportedly the application is successful if done properly (Adequate subgrade compaction, rolling of 5-6" of RAP with plenty of water)

- Given the absence of a project incentive, customers and producers utilize standard concrete mixes, rather than utilizing a concrete mix including recycled crushed concrete
- In general, the industry is not well informed with regard to recycling and reuse opportunities with the FDOT
- The development of alternative uses for RAP materials is needed to reduce the amount of excess RAP being produced

4.5 Update on Cost Information

Table 8 presents the latest cost information obtained by the research team for Florida materials. Limerock remains the low cost choice for roadway base material with an average market price of $7.50 per ton. The average market price for crushed concrete base material was $12.21 per ton. However, contractors consistently indicated a preference for the use of crushed concrete material for roadway base, citing crushed concrete's tolerance for wet conditions. The large volume of surplus RAP materials stock piled by contractors would seem to suggest a relatively low market value for the material. However, that logic apparently does not apply. Contractors view their RAP stockpiles as valuable inventory. The average market price for RAP was $15.00 per ton. Sources for natural mined concrete course aggregates are limited, and the commercial resale market is also limited. Most concrete producers obtain concrete aggregate from their own mines. Natural aggregate costs depend significantly on the mine location and the shipping distances. An average market price appears to be approximately $38.00 per ton.

Recyclers uniformly advised that the demand for their recycled concrete products exceeds the available supply of salvaged concrete. In general, they simply do not have large stockpiles of crushed concrete materials. This potential limited supply of material appears to be a

significant consideration for potential users such as contractors and concrete producers. The primary market for recycled crushed glass is the furnace industry. Given the relatively high cost of shipping collected glass to processing facilities, local processing of collected glass into fine aggregate may be economically feasible if a market for the ground glass existed with local ready mix concrete producers.

Table 8: Comparative Cost of Alternative Materials in Florida

Roadway Base Materials (average price per ton)		
Lime Rock	Crushed Concrete Base	RAP
$7.50	$12.21	$15.00
Concrete Aggregate Materials (average price per ton)		
Natural Quarry Stone (washed)	Crushed Concrete (#57 washed)	
$38.00	$19.20	
Fine Aggregates (average price per ton)		
Natural Sand (washed)	Crushed Glass Product	
$13.50	$110.00*	

Other Economic Factors:

- Delivery may add $1 to $3 per Ton to the cost for base materials and sand. Delivery of quarry stone may be higher depending on the quarry location and shipping destination.
- The design Structural Layer Coefficient for base materials should be considered when comparing installed costs
- Inconsistent supply of crushed concrete materials at recycling facilities significantly influences business decisions concerning product selection

* Price given is the commercial price at the centralized recycling center. Processing locally, would reduce shipping cost and result in significant cost reduction.

4.6 Summary

It appears that essentially all waste concrete delivered to recycling facilities is being recycled and reused in construction related products. True, only a small portion is being reused in FDOT projects. Nevertheless, the construction industry and the environment in general are benefitting. On the other hand, not all concrete construction waste is reaching recycling facilities which is an environmental loss. There appears to be a significant non-construction industry demand for recycled glass and as a consequence, collected glass waste is essentially all reused for non-construction purposes at a relatively high market value of approximately $110 per ton. However, there is a significant cost involved in shipping collected glass from local collection centers to regional processing centers. This suggest that local processing of glass into fine aggregates may be economically feasible if a market for the ground glass existed with local ready mix concrete producers. Finding practical solutions for the growing surplus of RAP is a more substantial challenge.

The following section of the report includes the results of a focus group effort to obtain further industry input and to develop recommended strategies for improving recycling and reuse opportunities.

5. Conduct Focus Group Discussions and Develop Recommendations

5.1 Introduction

This report section provides a summary of the input obtained from the research discussions with experienced industry professionals and experienced FDOT personnel. The focus of these discussions was to explore the feasibility of a number of suggested opportunities for improving recycling and reuse of materials in the FDOT construction program. A listing of the contributors is provided in Appendix A. Preliminary ideas were circulated for comments including perceived advantages, disadvantages and barriers to implementation. The outcome of the process was a group of strategies offered to the FDOT for its consideration.

5.2 Preliminary Ideas

5.2.1 Suggested Strategy A: Demolished Concrete Recycling

On FDOT projects with structural demolition, require that demolished concrete be delivered to a licensed recycling facility.

Objectives

- Increase the amount of recycled concrete from FDOT projects
- Reduction in the amount of Florida non-renewable resources being consumed for construction materials

Focus Group Input

- Specifying a single vendor for recycling will give that facility no competition and will drive the price to process the material up.
- Recycled structural concrete has been approved for use as rip-rap or ditch lining material onsite. This repurpose makes sense. This needs to be broadcast as a viable solution.
- FDOT has a developmental specification for Recycled Crushed Concrete as Roadway Base; Richard Hewitt is the man to talk about this. I can personally state crushed concrete makes for great base material especially in high water table conditions. Crushed Concrete loves water.
- As long as the recycled material meets specification, it shouldn't matter where the material is processed.
- Do not specify a sole source for processing. Contractors may want to process and size material onsite.
- Recyclers may increase price for taking concrete
- Reasonable haul distances will have to be established
- This will definitely increase the amount of concrete that is recycled
- Is there such a thing as a "licensed" recycling facility for concrete?
- How many concrete recycling centers are there in the State? Depending on the haul distance, the environmental benefit of recycling might be offset by the additional fuel expenditure, roadway wear and tear, etc.

Discussion

In a situation where there is only one viable recycler, the concerns about increased tipping fees appear to be valid. Some contractors routinely haul their salvaged concrete to their yard where it is stockpiled and crushed at a later date as needed. This would appear to be an acceptable alternative to requiring delivery to a commercial recycler. It is also true that with portable crushing equipment, salvaged concrete can be processed at the project site, which would also be an acceptable alternative. The concern regarding fuel consumption for hauling offsetting the benefit of recycling concrete is a valid consideration. The general consensus was that this strategy would be successful if recycling facilities were available.

5.2.2 Suggested Strategy B: Crushed Concrete Aggregate

Require that mix designs for non-structural concrete must utilize recycled concrete aggregates.

Objectives

- Increase the amount of recycled concrete from FDOT projects
- Reduction in the amount of Florida non-renewable resources being consumed for construction materials

Focus Group Input

- Availability would have to be confirmed on a project by project basis
- Unless the research says otherwise, I think this could be a promising idea.
- If implemented we'd have to establish criteria for use, gradation limits, and other areas to ensure quality concrete. My gut feeling is that it would be possible to implement.

Discussion

The FDOT has developed a standard specification for crushed concrete aggregate as a component of non-structural concrete. This specification is included in the current edition of the Standard Specification for Roads and Bridge Construction.[9] The question of availability is a valid issue. Availability would have to be confirmed on a project by project basis. The larger urban locations do have concrete crushing facilities. More remote project sites may have an availability issue. The general consensus was that this strategy would be successful if recycled crushed concrete was available.

5.2.3 Suggested Strategy C: Add Recycling to DB RFP Criteria

In Design-Build Project RFP under the typical section "Evaluation Criteria", subsection "Design", include in the list of elements to be considered "Design Considerations that Improve Recycling and Reuse Opportunities".

Objectives

- Promote recycling and reuse opportunities on FDOT construction projects

Focus Group Input

- Agreed, If FDOT awarded technical points for recycling there would be more recycling.
- Simple and Effective idea. Building can achieve LEED award levels, roadways should as well.

[9] Specification Section 901-5 Reclaimed Portland Cement Concrete, 2014 Specifications for Roads and Bridge Construction, FDOT

- I would not be opposed to the suggested strategy as it relates to our Design-Build Technical Proposal requirements.
- I would not limit this to just Design-Build projects and would suggest that similar language be included In the Scope of Services where the Department hires a Consultant Designer to develop the plans for Conventional projects as well.
- I have seen this done on Design-Build proposals.

Discussion

This strategy was universally endorsed by the focus group. It has the potential to mobilize the creative potential of both the construction and design organizations. It also has the advantage of providing a clear incentive, without issuing a mandate. Additionally, the suggestion that this approach also be used in acquiring design services makes good sense. Accordingly, an additional strategy to include design services procurement was developed.

5.2.4 Suggested Strategy D: Recycling Web Page

Provide a link to the current recycling web page on the home page of the State Materials Office. Add additional content (recycling updates, project show case, news).

Objectives

- Promote recycling and reuse opportunities on FDOT construction projects

Focus Group Input

- A DCE MEMO promoting recycling and reuse materials and promising quick approval would be more effective than building a website.
- Award bonus points to contractor's CPPR and CEI Consultant grades for recycling and reuse would give construction professional incentive to use recycled material.

- Websites lose interest and cost a pretty penny to maintain
- If the recycling website already exists, this strategy seems to be easy to implement. The Construction Office already has a section for the Environment on our homepage and a link to the recycling page would be a good fit.

Discussion

The State Materials Office currently has a webpage dedicated to recycling. However, providing a link on the State Materials Office home page would further demonstrate a commitment to recycling. Providing case study project examples on the recycling page would also be helpful. Additionally, the focus group suggested providing links to the Recycling page on the Construction Office page and on the Design Office pages. The focus group was uncertain of the total value of this strategy. However, implementation requires minimal effort and is therefore justified.

5.2.5 Suggested Strategy E: Divert RAP Materials to Local Governments

On projects with significant pavement milling, require that a portion of the RAP is to be delivered to county or city public works facilities.

Objectives

- Increase the amount of RAP that is being reused in Florida
- Decrease surplus stockpiles of RAP material

Focus Group Input

- As a HMA supplier, we count on every ton of millings be delivered back to the plant for use in the next asphalt project or be used on the project.

- Requiring milling material be delivered to state or county yards will increase cost to FDOT and Counties on their next paving project. Contractors would need to figure the haul cost from FDOT and County yard back to the plant. (Double handling of the material)
- Milling piles requires a large storage facility, state and county yards will be quickly filled up. Not to mention, this will make their yard a certified material facility which will need to be QC for material quality.
- Do not implement this suggestion. Education is better served and more cost effective then making the RAP material stop at a temporary home before traveling back to a HMA facility for processing.
- First and foremost, the researchers have to determine if cities and counties actually want it. A fair number of cities and counties don't use RAP in their mixes so demand may be limited.
- If we did require it to be given to cities and counties, we'd likely have it left somewhere on the project site and cities and counties would be responsible for loading and transporting the material to offsite locations. Requiring contractors to deliver the product to different counties and cities is not cost effective for the Department.
- The FDOT needs to work on developing mix specifications allowing more RAP in the mix for low volume roads. If the FDOT would take the lead, counties and cities would follow.

Discussion

Although, contractors currently are only able to recycle a small portion of the RAP materials generated from their milling operations, they view the RAP material as an asset. The indication is that the contractors would push back against a plan to give a portion of the RAP to cities and counties. A more serious concern is the logistics of delivery and storage. The focus group predicts situations where the county or city is not ready to receive the material and as a result there are delays and additional cost for trucking. Accordingly, this strategy is not recommended.

Fundamentally, what is needed is the development of a specification for the use of RAP as a surface treatment for low volume roads. Given a viable option for using RAP on previously unpaved roads, local governments may be encourage to utilize RAP surfacing. Therefore, implementing this research need has been recommended as a strategy.

5.3 Final Revised and Recommended Strategies

5.3.1 Evaluation of Preliminary Strategies

The following criteria were used to evaluate each suggested strategy:

- should be no significant barriers to implementable by the FDOT
- should be reasonably acceptable to industry stakeholders
- should be reasonably certain of producing the desired outcome

Additionally, consideration was given to the concept that it is better to offer incentives rather than to mandate requirements. Mandated requirements often result in additional costs. For example, the use of RAP in hot mix asphalt mixes is permitted (perhaps facilitated) but not

required. The best environmental solutions are the ones that are also economically attractive. However, there may be justification for enforcing requirements that reduce the consumption of our non-renewable resources. In many cases, economic viability is preceded by an administrative or statutory requirement.

As a result of the focus group review process preliminary strategies were evaluated and either recommended or not recommended. Some strategies were modified and additional strategies were developed. Table 9 presents a summary of the developed strategies.

Table 9: Focus Group Strategies

	Strategy	**Focus Group Outcome**
A	On FDOT projects with structural demolition, require that demolished concrete be delivered to a recycling facility	Recommended
B	Require that mix designs for non-structural concrete must utilize recycled concrete aggregates	Recommended
C	In Design-Build Project RFP under the typical section “Evaluation Criteria”, subsection “Design”, include in the list of elements to be considered “Design Considerations that Improve Recycling and Reuse Opportunities”	Recommended
D	Provide a link to the current recycling web page on the home pages of the State Materials Office, Construction Office and Design Office. Add additional content (recycling updates, project show case, news)	Recommended
E	On projects with significant pavement milling, require that a portion of the RAP is to be delivered to county or city public works facilities	Not Recommended
F	Implement a research initiative to develop an engineering specification for the use of RAP material as a surfacing for low volume roads	Recommended
G	In Design Consultant Procurement under the “Evaluation Criteria”, subsection “Approach”, include in the list of elements to be considered “Design Considerations that Improve Recycling and Reuse Opportunities”	Recommended

5.4 Recommended Strategies

5.4.1 Recommended Strategy A: Demolished Concrete Recycling

On FDOT projects with structural demolition, require that demolished concrete be delivered to a recycling facility.

Implementation

- Availability of recycling facilities within reasonable distance of project to be verified during design as a prerequisite to implementation
- Verification of delivery by recycling facility receipts
- Crushing on site to be permitted as an alternative
- Implementation by plan note or pay item note

5.4.2 Recommended Strategy B: Crushed Concrete Aggregate

Require that mix designs for non-structural concrete must utilize recycled concrete aggregates.

Implementation

- Availability of recycled concrete aggregate within reasonable distance of project to be verified during design as a prerequisite to implementation
- Verification of use through mix design and quality management
- Implementation by plan note or pay item note

5.4.3 Recommended Strategy C: Add Recycling to Design-Build RFP Criteria

In Design-Build Project RFP under the typical section "Evaluation Criteria", subsection "Design", include in the list of elements to be considered "Design Considerations that Improve Recycling and Reuse Opportunities".

Implementation

- This addition to the RFP language on Design-Build projects can be implemented on all new projects

5.4.4 Recommended Strategy D: Recycling Web Page

Provide a link to the State Materials Office current recycling web page on the home pages of the State Materials Office, Construction Office and Design Office. Add additional content when available (recycling updates, project show case, news on examples of recycling successes).

Implementation

- The webpage links can be added at once
- Adding additional project examples, will require soliciting input from district offices

5.4.5 Recommended Strategy F: RAP Research Initiative

Implement a research initiative to develop an engineering specification for the use of RAP material as a surfacing treatment for low volume roads.

Implementation

- The target low volume roads are not within the State road system managed by the FDOT, however, the major portion of the surplus RAP originates from State roads.

- It is reasonable to believe that the FDOT has some responsibility for resolving the surplus RAP problem and should support research initiatives to reduce the RAP surplus
- Development of an engineering specification would facilitate the use of RAP on local roads

5.4.6 Recommended Strategy G: Add Recycling to Design Procurement Criteria

In Design Consultant Procurement under the "Evaluation Criteria", subsection "Approach", include in the list of elements to be considered "Design Considerations that Improve Recycling and Reuse Opportunities".

Implementation

- This addition to the evaluation criteria language on consultant procurement can be implemented on all new projects

5.5 Summary

Engineering research analysis and focus group input resulted in seven tentatively recommended strategies for improving recycling and reuse opportunities on FDOT projects. **Tentative strategy E: Divert RAP Materials to Local Governments** was ultimately dropped because of anticipated construction industry opposition and possible logistical problems. It was believed that **Strategy F** concerning developing an engineering specification for the use of RAP on low volume roads is a prerequisite to utilizing RAP as a low volume road surfacing treatment. The thinking is that we first need to develop a recognized engineering use for the material, which would encourage local use of the surplus RAP.

Strategies C, D, and G concerning design procurement and website structure can be implemented as soon as possible. **Strategies A and B** concerning adding recycling requirements to construction contracts should be tried on test projects prior to general implementation. **Strategy F** concerning the implementation of a research initiative for using RAP as a low volume road surface treatment can be implemented with FDOT management approval. Including a demonstration of the results in the research scope would be helpful in promoting RAP usage.

5.6 Recommendations

The research team recommends that the FDOT review the recommended strategies offered as a result of this research project and initiate a process for implementation. Further, it is recommended that the FDOT initiate a process to track and report the amount of materials that are recycled and reused in their construction work program. This information would be valuable in monitoring the success of the recommended strategies. The final recommendation is that the FDOT continue to support research initiatives relating to recycling and reuse of construction materials.

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Appendix A: Letter to DOTs and Responses

A.1 Letter to DOTS

Dear _____,

I am a PhD student at the University of Florida, working as a research assistant for Dr. Ralph Ellis. We have been contracted by the FDOT (#BDV31) on a project to enhance the use of recycled construction waste materials throughout the state of Florida, such as RAP and crushed concrete. We have been asked to reach out to each state transportation department to gather input about their experiences in regards to strategies for increasing the use of recycled materials on construction projects. In your state have there been projects where the contract has required the use of recycled materials in lieu of virgin material? Or have there been contracts which give incentive for the use of recycled materials? Any input on this would be greatly appreciated.

Thanks for your time,

_____

A.2 Responses

Table A1: Responses from DOTs

STATE	RESPONSE
AK	No email response. Spoke with Steve Saboundjian on telephone. Alaska has not mandated or offered incentives for recycled materials. Current specs allow up to 20% RAP in base layers. Newly anticipated specs will allow up to 25% RAP in base layers as well as up to 15% in surface course.
AL	Section 410 of our Specs allows use of recycled asphalt plant mix (RAP) and reclaimed asphalt shingles (RAS). The Contractor has the option to use RAP and RAS in accordance with the requirements given in a table in our specs or otherwise shown on the plans.
AR	Arkansas has not included any recycled material requirements or incentives in construction contracts. We do, however, have Standard Specifications and Special Provisions to allow for the use of recycled materials. Following are the three recycled materials currently allowed by Special Provision or Standard Specifications: Removing Existing Portland Cement Concrete Pavement – Special Provision allows for the removal of existing Portland Cement Concrete Pavement (PCCP) to be crushed and used as aggregates in various other items in the contract. To date, 406,329 Square Yards of PCCP have been recycled. Recycled Asphalt Shingles – Special Provision allows for the use of recycled asphalt shingles in asphalt mix designs. Currently Arkansas only allows the inclusion of shingles directly from the factory (tear offs are not permitted); however, we are considering allowing tear offs in the near future. To date, 18 contracts have used asphalt mix designs containing recycled shingles. Recycled asphalt Pavement (RAP) - Standard Specifications permit a mixture of RAP material containing a minimum 70% virgin material. I do not have a quantity of RAP used, but it is used frequently in asphalt mix designs used on our projects.
AZ	The Arizona Department of Transportation allows up to 25% RAP usage in its End Product AC mixes for material placed in lower lifts (minimum of 2 inches below the surface) and up to 20% in the top 2 inches. Our specification is permissive and does not require the use of RAP; however, the majority of contractors are utilizing RAP in the End Product mixes they place. Crushed concrete is not allowed as aggregate in our AC mixes and has not been utilized in Portland Cement Concrete mixes.

Table A1, continued

STATE	RESPONSE
CA	The California Department of Transportation has considerable experience with use of recycled materials and is continuing to examine potential uses for others. The 2010 Standard Specifications and related standard special provisions can be located at the following website: http://www.dot.ca.gov/hq/esc/oe/construction_standards.html Some examples of recycled materials that have been standardized into our construction contracts for allowable use are as follows: Rigid Plastic Barriers within our temporary sediment control (2010 Standard Specifications, Section 13-6) allows the use of recycled materials. Recycled Steel Shot is allowed for use in cleaning bridge surfaces (2010 Standard Specifications, Section 15-5). Recycled Water is allowed for certain uses (2010 Standard Specifications, Section 17-1). Recycled Pulp Fiber is allowed for use as cellulose fiber in erosion control (2010 Standard Specifications, Section 21-1.02E). Recycled Wood Products are allowed as compost (2010 Standard Specifications, Section 21-1.02M). Recycled Product is allowed in use of plastic lumber (2010 Standard Specifications, Section 57). Recycled Steel Abrasives are allowed in use of painting preparation (2010 Standard Specifications, Section 59). Recycled Paint is allowed for certain applications (2010 Standard Specifications, Section 91-3.03). Allowable use of reclaimed processed materials for shoulder backing including asphalt concrete, Portland cement concrete, cement treated permeable base and lean concrete base (2010 Standard Specifications, Section 19-9.02). Allowable use of reclaimed processed materials for aggregate subbase including asphalt concrete, Portland cement concrete, cement treated permeable base and lean concrete base (2010 Standard Specifications, Section 25-1 also see Standard Special Provisions 99-02234 & 99-02236 [free draining granular material]). Allowable use of reclaimed processed materials for aggregate base including asphalt concrete, Portland cement concrete, cement treated permeable base and lean concrete base (2010 Standard Specifications, Section 26-1). Allowable use of reclaimed processed asphalt concrete for aggregates in lean concrete base (2010 Standard Specifications, Section 28-1). Allowable use of reclaimed asphalt pavement as aggregate in hot mix asphalt (Type A or B), not to exceed 25% of the aggregate blend (2010 Standard Specifications, Section 39-1.02F). Allowable use of reclaimed aggregates from plastic concrete for use in production of new concrete (2010 Standard Specifications, Section 90-1). Allowable use of crushed concrete for aggregates used in the production of minor concrete (2010 Standard Specifications, Section 90-2). Other examples of use of recycling materials on our contracts include the following design practices. Required use of additives (e.g. cement or lime) to existing soils for stabilization purposes when the existing soils are unsuitable in present state (2010 Standard Specifications, Section 24 and related Standard Special Provisions). Allowing use of processed glass within subbases or aggregate bases (2010 Standard Special Provisions, 25-1 & 26-1). Full depth reclamation with additives (e.g. cement or foamed asphalt) as part of the roadway's structural section (2010 Standard Special Provisions, 30-2 & 30-4). Pulverization of existing roadway with cement additive to serve as base within new roadway's structural section (2010 Standard Special Provisions, 30-3). Rubberized HMA (2010 Standard Specifications, Section 39). In addition, our Division of Design – Resource Conservation Program maintains a website that addresses many of these conservation/recycling practices. This website is located at: http://www.dot.ca.gov/hq/oppd/rescons/ Caltrans also produces an annual report to the legislature pursuant to Senate Bill 876 on the use of waste and used tires (see webpage: http://www.dot.ca.gov/hq/oppd/rescons/sb876/Final-2011-SB-876-Waste-Tire-Report.pdf). The following website may also be helpful: http://www.calrecycle.ca.gov/condemo/Roads/CalTrans.htm. The use of rubberized HMA is an example of where the department has required the use of recycled material (portion) in lieu virgin materials. In general, we will allow the use of recycled/reclaimed materials as opposed to requiring their usage. To the best of my knowledge we have not offered direct incentives for the use of recycled products within our contracts.
CO	A study published in 2007, "Materials Recycling and Reuse - Finding Opportunities in Colorado Highways", best characterizes CDOT's practice and future goal for recycling. It is available on our web site at: http://www.coloradodot.info/programs/research/pdfs/2007/epagrant.pdf/view Most notable in terms of tonnage is our use of recycled asphalt pavement (RAP). Although they are not standard practice we have also tried shredded tire backfills, a recycled tire noise barrier, and a recycled-tire faced rockfall barrier.

Table A1, continued

STATE	RESPONSE
CT	Connecticut Department of Transportation Standard Specifications allow the use of recycled materials such as recycled asphalt pavement and crushed recycled container glass for use in asphalt pavements; fly ash and slag for use in Portland Cement Concrete; and reclaimed concrete aggregate, reclaimed miscellaneous aggregate, and reclaimed waste for use in granular fill, subbase etc... Our standard specifications are available on-line at http://www.ct.gov/dot/cwp/view.asp?a=1385&q=530802. We are in the process of allowing recycled asphalt shingles to our standard specifications. We have had a few pilot projects in which we require the use of recycled materials, but we generally do not require it. I believe the general philosophy of the Department is that if the use of recycled materials is financially beneficial, then our specifications should permit the use up to a technically sound limit. To my knowledge, we have never offered direct incentives for the use of recycled materials.
DE	DelDOT has had some projects where recycled materials were required to be re-utilized/re-incorporated but for the most part, it's the contractor/suppliers option. With our typical responsive low bidder system for awarding work, we do not give specific incentives for recycled materials.
GA	Thank you for contacting the Georgia Department of Transportation. We received your inquiry and forwarded it to Marc Mastronardi. You may contact him direct at 404-631-1971 or email at mmastronardi@dot.ga.gov
HI	No email response. Called and left phone message.
IA	In Iowa we have not required to contractors to use recycled material. However, most contractors have realized the benefits of the recycled products and have worked with us to allow recycled products in our specifications. The incentive to use the recycled products in our jobs would be for the contractor to figure out how to efficiently generate and product quality recycled products that meet our allowable standards and win contracts by accounting for this in their bids.
ID	No email response. Called and left phone message
IL	While IDOT rarely mandates the use of a recycled material, we do allow contractors many recycle and reclaimed material options. IDOT has not provided a direct incentive to use a reclaimed material. Our efforts can be seen in the information below: General recycling: http://www.dot.il.gov/materials/research/pdf/prr161.pdf Shingle recycling: http://www.dot.il.gov/materials/research/pdf/prr163.pdf New effort using high RAP, shingles and crushed concrete in HMA http://www.dot.il.gov/press/r042613.html
IN	In Indiana we have gradually increased the use of recycled materials by performing research and increasing the allowable % of recycled material for asphalt pavements. Our current specifications allow up to 50% recycle asphalt pavement to be incorporated into hot mix asphalt, although I do not believe we have seen many mixes with that much recycled material. 35% is common. We do not offer incentives, but believe we get a benefit as the use of recycled material is factored into the contractor's bid price. When the contractor removes the old asphalt that material becomes his property and it is taken back to the asphalt plant. The contractor decides how much to incorporate into his design. The RAP is also used in private work. We are currently conducting research to explore the concept of using recycled concrete in new concrete mixtures. Currently we do not allow that practice due to concerns with the quality of the concrete. We are concerned with the effect of unhydrated cementitious materials in the crushed concrete & the durability of the resulting mix. We do use crushed concrete as fill material and on most jobs all of the old concrete is crushed at the jobsite and incorporated into the fill. The cost of onsite crushing is less than the cost of trucking in other materials. We do require all of the concrete to be used onsite before we pay for virgin materials. Our concrete specifications allow up to 20% of the cement to be substituted with fly ash. We have also constructed jobs using recycled tire shreds, spent foundry sand and fly ash as fill materials. Those projects are less cost effective due to trucking and special handling costs, so the number of projects has been limited.

Table A1, continued

STATE	RESPONSE
KS	For the use of RAP our contractors will use as much as we allow so we have not had to put an incentive on the use of RAP. With the cost of asphalt binder and the limited aggregate resources we have within Kansas we have not had to put any incentive to get them to use RAP. With crushed concrete we do not allow the use of it very often in the PCCP, but we will allow the use of it in our cement treated base, so typically the contractors will use almost all of the removed PCCP in the cement treated base. Due to the poor aggregate we have and concerns with D-cracking we do not allow the use of it in PCCP unless we have tested it and know that it is not susceptible to D-cracking. Again for the most part the contractors are pushing us to use more recyclable materials so we have not had to put incentives on the use of it. We do have one instance that we require the use of recycled materials in lieu of virgin material. We will do what we call a subgrade modification mainly as a working platform for paving to where we mix aggregate with soil and fly ash. We have required the use of RAP instead of aggregate for the SUBMOD when RAP is available.
KY	In your state have there been projects where the contract has required the use of recycled materials in lieu of virgin material? Yes. Or have there been contracts which give incentive for the use of recycled materials? No. It is usually done because it is an incentive itself because less virgin material is necessary.
LA	We “allow” RAP and crushed concrete to be used in our projects but have not used incentives to encourage their use.
MA	We are not aware of any projects where the DOT has mandated the use of recycled material in lieu of virgin material. We are also unaware of any contracts where the DOT has incentivized the use of recycled materials, though it is well established that the DOT’s current allowance of higher RAP contents than those currently being used as an incentive for producer’s to use additional RAP. The DOT has an upcoming initiative to mandate the use of higher levels of RAP on several projects, though the presumption is that performance based mixture specifications would be used for the Hot Mix Asphalt on these projects.
MD	I will ask our Director of our Office Of Materials and Technology to respond to your questions.
ME	No email response. Called and left phone message
MI	We currently have a permissive specification which allows the use of RAP and Recycled Asphalt Shingles (RAS). Prior to adding the permissive use of RAS to our RAP specification we had trial projects where we required it. We had a pilot project this past year where we required the use of recycled tire rubber. To my knowledge no incentives have been given for using recycled materials. I have copied our Materials Engineer (John Staton) for further input to your question.
MN	In your state have there been projects where the contract has required the use of recycled materials in lieu of virgin material? We have only required the use of recycled materials for Full Depth Reclamation or Cold in place recycling processes. Or have there been contracts which give incentive for the use of recycled materials? No
MO	This is an automated response from the Missouri Department of Transportation's web page to let you know your comment has been received. Your e-mail will be forwarded to the appropriate division or district to be reviewed and responded to by MoDOT personnel.
MS	Yes, recycled concrete pavement to be used on shoulders and as base material usually as an alternate. RAP in asphalt pavement is not “required” but mixes have at least 15% RAP and can have up to 30%. Incentives are not used
MT	No email response. Called DOT and left message
NC	We do not require recycling but we do have a provision to encourage recycling and tracking. See below link. The attached provision should be included in each contract encouraging the use recycled material as does Article 104-13 in the Standard Specifications (see page 1-39, or page 47/815 in 8https://connect.ncdot.gov/resources/Specifications/Specification%20Resources/2012%20Standard%20Specifications.pdf).

Table A1, continued

STATE	RESPONSE
ND	We use recycled materials in our projects. The most commonly used materials are RAP in asphalt pavements and as a portion of aggregate bases, crushed concrete in bases and in some cases PCC . We also use fly ash in our concrete pavements. Many of the projects require the use of the recycled materials, however, we have not offered an incentive to use recycled materials.
NE	Had phone conversation with Robert Rea. RAP is used a lot in Nebraska. Estimated average RAP content in 2012 was over 37%.
NH	Phone conversation with James Bowles. New Hampshire has permissive specifications but RAP supply is low therefor mandates and incentives are not necessary
NJ	NJDOT has a long history with recycling. As a general policy, we have a permissive specification for those recycled materials that have been determined to perform as well as the virgin material. We have not done much in requiring the use of recycled products except as pilot projects in order to gain experience with a new recycled material. In 2011, we had a pilot project which required a MINIMUM percent RAP so that we could test out the concept of performance based specifications for High RAP mixes. Attached is a Powerpoint presentation that I did on this project. As far as incentives go, we had a glass incentive program in the late 1980's / early 1990's that was sponsored by the New Jersey Department of Environmental Protection. We paid $1 /ton of hot mix asphalt that contained recycled container glass. NJDEP was looking to help the container glass recycling folks with their waste stream.
NM	Had phone conversation with James Galledos. New Mexico has permissive specifications, but has never used mandates or incentives.
NV	Nevada uses RAP in our plantmix, in our aggregate base sections, and allow the use of recycled concrete in our aggregate base sections. No incentives have been given for using recycled materials, but they are used since they are economical to use. Also, we do not mandate the use of recycled materials in our projects. Call/email me if you have any questions.
NY	NYSDOT has a favorable and supportive stance toward the use of recycled materials. The Department has reviewed its specifications for construction materials and has made provisions for the use of recycled materials wherever feasible. As Contractors generate waste on our construction contracts (i.e., Reclaimed Asphalt Pavement (RAP), Recycled Concrete Aggregate (RCA), etc.) they often find it advantageous to re-use these materials in the new work. From a material performance aspect, our concern is that the recycled material should perform at least as well as the traditional material, at similar cost. Sometimes the benefit of recycled material use is shortened time rather than reduced cost, but the overall goal is to realize some material benefit to the State. For these situations we allow the marketplace to dictate the use of recycled materials. We have found that this works better than mandates – we get better quality, and the Contractor is happier. In rare situations, we encourage the use of recycled materials in order to meet a particular goal, and in those cases we provide an incentive for their use. As an example, we selected particular projects on which to place tire derived aggregate instead of soil for embankments, as the goal was to remediate dozens of waste tire stockpiles across the state. State legislators passed a law to provide funding for this specific purpose. We were successful in this effort and were able to remediate the waste tire stockpiles ahead of schedule. In other cases, our material specifications actually require the use of recycled materials. We do this because the recycled materials enhance performance in some way, or imbue desirable properties to the final product. An example of this is High Performance Concrete, which requires fly ash in the mix for its pozzolanic properties. Note that these last two situations are rare in comparison to all of our material specifications. In the majority of cases, we let the market drive the use of recycled materials.
OH	No email response. Called and left phone message
OK	Oklahoma allows up to 25% RAP in their mixes but does not mandate the use or offer incentives
OR	No email response. Called and left phone message for Margie Bradway

Table A1, continued

STATE	RESPONSE
PA	Pennsylvania does not offer any incentives in using recycled material. We do allow the use of RAP in our mixes and it is considered (black gold) for the industry. As for concrete we have specifications allowing crack and seat and break and seat to be used as base materials. I will forward you a link to our specification manual Friday as I am out of the office tomorrow. RAP use is encouraged and is used extensively in pavement designs. We encourage the use of RAP. As stated above RAP is (Black Gold) and we really do not need to encourage contractors to use it. When I get back in the office I will send you a link to our Specification Manual Pub 408.
RI	I am not aware of any projects requiring the use of recycled materials. We do allow, not require, a percentage of RAP (up to 25%) in all pavement layers, except the final surface layer. We have not included an incentive for the use of recycled materials on projects.
SC	No email response. Called and left phone message for Merrill Zwanka
SD	We have most of our contracts require the use of recycled material (especially asphalt). Others encourage it but don't mandate it which allows the Contractor the choice – the hope is to get better prices. For more detailed information, I have cc our Pavement Design Engineer, Gill Hedman and you can contact him.
TN	TDOT specifications allow the use of RAP in varying amounts depending on the type of asphaltic mixture. (See Supplemental specifications SS300 and SS400- http://www.tdot.state.tn.us/construction/specs.htm). We are currently researching the use of RAS/Recycled Asphalt Shingles. We also allow recycled concrete to be blended with virgin aggregate in aggregate base mixtures. (See 903.05- http://www.tdot.state.tn.us/construction/specbook/2006_Spec900.pdf) We have not required the use of recycled materials in lieu of virgin materials, nor have we provided incentives for using recycled materials.
TX	Many TxDOT roadway specifications either call for or allow for the use of recycled materials. In addition, we used to allow for our contracts using recycled materials to withhold 4% retainage rather than the normal 5% retainage. However, we no longer require retainage on our construction projects. Information on our use of recycled materials used in roadway projects is located at this link: http://crossroads/org/gsd/Recycling/roadremats.htm
UT	We have never required the use of recycled material in our contract, but using recycled asphalt is always encouraged in our Hot Mix Asphalt Pavement Bids. We allow up to 25% Recycled Asphalt Pavement Material in our Asphalt Pavement Specification. We do not give incentive for using recycling material; however, contractors will have cost saving and bidding advantage by applying recycled material in the pavement. Last year, we finished 1,094,964 tons of Asphalt Pavement and used 190,090 tons of Recycled Asphalt material. In our current specification, we allow using recycled cement concrete as embankment and backfill material. We have some projects using crushed concrete pavement as untreated base material in the past. But this is not in our Standard Specification. We are continuously testing and experiencing new pavement methods to improve quality sustain our resource and reduce environmental impact. About 20% of our last year's asphalt pavements applied Warm Mix technology. We also tried Cold in Place Recycling in two of our last year's asphalt pavement projects with the quantity of 16,339 tons.
VA	Visit all DOT sites and search their specifications as the below example. Visit our website at: http://www.virginiadot.org/business/resources/const/2007SpecBook.pdf Word search for all the recyclable materials you can think of and all terms pertaining to recycling.
VT	Had phone conversation with Mark Woolaver. Vermont has permissive specifications but RAP supply is low therefor mandates and incentives are not necessary
WA	No email response. Called and left phone message
WI	No email response. Called and left phone message
WV	The WVDOH makes use of recycled materials and places a high priority on environmentally friendly construction practices as part of its core mission. We routinely utilize recycled materials such as RAP, slag aggregates, and fly ash in most of our construction projects. At this point, I am not aware of any contracts where the WVDOH has required or provided incentives for the use of recycled materials.

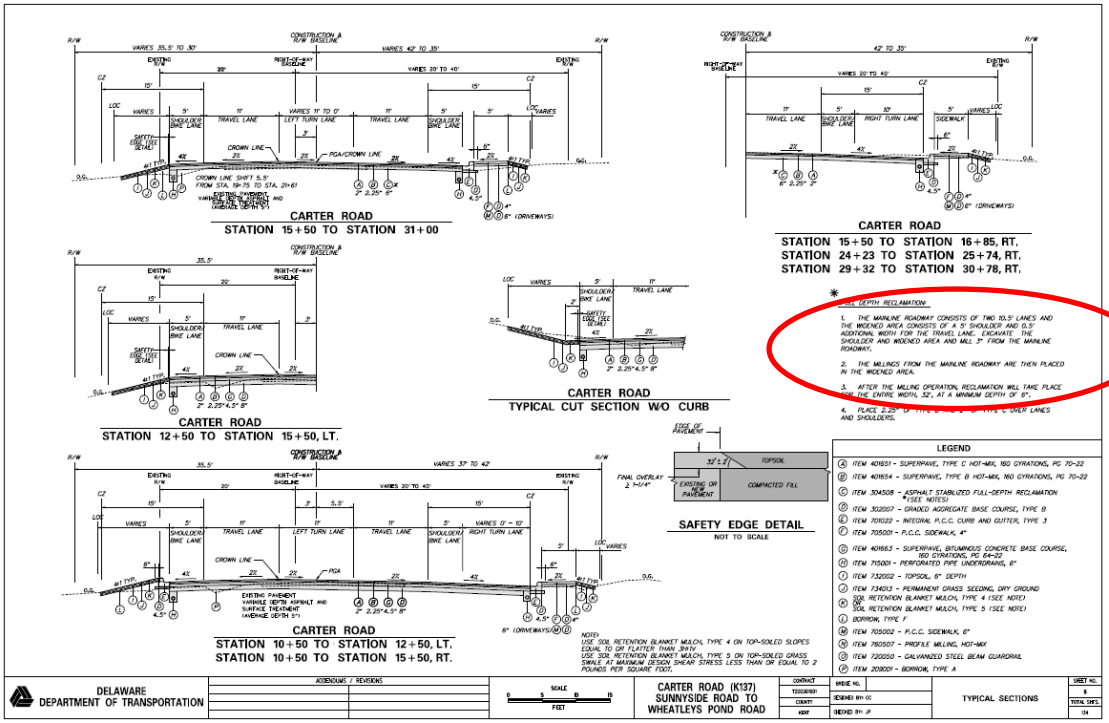
Table A1, continued

STATE	RESPONSE
WY	WYDOT has required the use of recycled material but it doesn't happen very often. When we have, it's usually a requirement to used recycled material harvested from the project. Typically crushed concrete, recycled crushed base or RAP incorporated into a blended base product. Requiring RAP from the project to be used in the hot plant mix hasn't happened for many years. We have never given incentives to contractors for their use of recycled materials.

Appendix B: Samples of Contract Specifications Promoting Recycled Materials

B.1 Mandates

B.1.1 Delaware

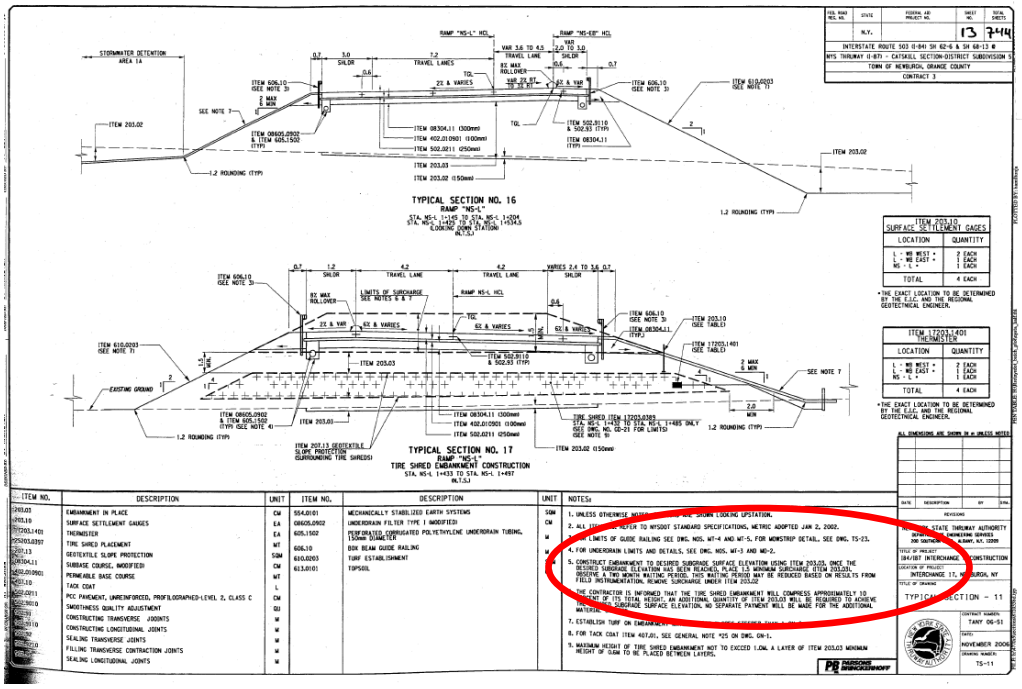


"1. THE MAINLINE ROADWAY CONSISTS OF TWO 10.5' LANES AND THE WIDENED AREA CONSISTS OF A 5' SHOULDER AND 0.5' ADDITIONAL WIDTH FOR THE TRAVEL LANE. EXCAVATE THE SHOULDER AND WIDENED AREA AND MILL 3" FROM THE MAINLINE ROADWAY

2. THE MILLINGS FROM THE MAINLINE ROADWAY ARE THEN PLACED IN THE WIDENED AREA

3. AFTERN THE MILLING OPERATION, RECLAMATION WILL TAKE PLACE FOR THE ENTIRE WIDTH, 32', AT A MINIMUM"

B.1.2 New York



"5. CONSTRUCT EMBANKMENT TO DESIRED SUBGRADE SURFACE ELEVATION USING ITEM 203.03. ONCE THE DESIRED SUBGRADE ELEVATION HAS BEEN REACHED. PLACE 1.5 MINIMUM SURCHARGE (ITEM 203.03). OBSERVE A TWO MONTH WAITING PERIOD. THIS WAITING PERIOD MAY BE REDUCED BASED ON RESULTS FROM FIELD INSTRUMENTATION. REMOVE SURCHARGE UNDER ITEM 203.03

6. THE CONTRACTOR IS INFORMED THAT THE TIRE SHRED EMBANKMENT WILL COMPRESS APPROXIMATELY 10 PERCENT OF ITS TOTAL HEIGHT. AN ADDITIONAL QUANTITY OF ITEM 203.03 WILL BE REQUIRED TO ACHEIVE THE DESIRED SUBGRADE SURFACE ELEVATION. NO SEPERATE PAYMENT WILL BE MADE FOR THE ADDITIONAL MATERIAL OR WORK"

B.1.3 Wyoming

WYOMING DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
REUSED SURFACING

Project No. N311075
Yellowstone Park - Cody
Wapiti West Section
Park County

REFERENCE: The 2010 Edition of the Wyoming Department of Transportation's Standard Specifications for Road and Bridge Construction.

DESCRIPTION: This special provision describes the requirements of loading, hauling, stockpiling, and placing reclaimed asphalt pavement (RAP) generated from milling existing plant mix pavement.

MATERIALS: Use RAP cold milled from the existing roadway. Produce 2 inch maximum size material.

CONSTRUCTION: Cold mill plant mix pavement from the existing roadway at the locations shown in the contract in accordance with Subsection 202.4.5, Removal of Surfacing, Concrete, Sidewalks, Curbs, Gutters, Median, Double Gutter, Etc. Stockpile the plan quantities of RAP designated for use as temporary surfacing at locations along the project approved by the engineer. Haul and stockpile the remaining RAP at the North Fork Pit for use in the pit run subbase.

Remove the RAP from the stockpiles and place as temporary surfacing at designated locations along the roadway to facilitate construction traffic. Spread, shape and roll the RAP to provide a smooth riding surface.

Surplus RAP not used for temporary surfacing will remain the property of the department. Haul and stockpile the remaining RAP at the North Fork Pit.

MEASUREMENT and PAYMENT: The engineer will measure:

Milling, hauling and stockpiling the RAP by the square yard. The measurement will be computed using the neat lines for roadway width including one-half the milled taper widths.

Loading, hauling, spreading, shaping, and compacting the RAP designated for temporary surfacing by the cubic yard based on the measured volumes removed from the stockpiles.

The department will pay as follows:

Measure to the Pay Item	Pay to the Pay Unit	Nearest	Nearest
Milling Plant Mix	SY	0.1 ft	SY
Reused Surfacing	CY	0.1 ft	CY

When specified, the engineer will measure and pay for:

1. Water used for compaction and to aid in dust control in accordance with Section 209, Watering.

2. Pit Run Subbase in accordance with Section 301, Aggregate Subbase, Base Courses, and Bed Course Material.

Hauling and stockpiling the RAP material are incidental to the Milling Plant Mix and Reused Surfacing bid item bid items.

07-02-13

B.1.4 Kansas

Construction Sequence:
1. Excavate 19.5" of existing asphalt and soil. Establish a 1.6% cross slope on the roadway.
2. Place 4" of asphalt millings (120 pounds per cubic foot) 31.05' wide on the roadway. This will be paid for with bid item "Aggregate Subgrade Modification (Millings)".
3. Combine the 4" of asphalt millings with 1" of the underlying soil, along with fly ash and water. Compact and trim the top of the subgrade to 3" above the excavation line shown in the typical above (i.e., 16.5" below the existing surface). This work will be paid with bid item "Manipulation for Aggregate Subgrade Modification (Millings)(Fly Ash)".
NOTE: Quantities for the fly ash have been calculated at 10% by weight of the soil/millings mixture (140 pounds per cubic foot). Quantities for the water have been calculated at 12% by weight of the soil/millings mixture (140 pounds per cubic foot). The exact proportions will be determined in the field.

B.1.5 Michigan

This is a sample from a proposal for a pilot project requiring recycled tires

DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

FOR

CRUMB RUBBER MODIFIED HOT MIX ASPHALT (HMA) MIXTURES

CFS:KPK 1 of 4 APPR:JWB:CJB:10-19-12

a. Description. This work consists of furnishing and placing Hot Mix Asphalt (HMA) Crumb

Rubber mixture(s) using Superpave mix design methods. Furnish Superpave HMA Crumb Rubber mixtures according to section 501 of the Standard Specifications for Construction, except as modified herein. This specification includes mix specifications for Crumb Rubber Terminal Blend

(CRTB) and Crumb Rubber Wet Process (CRWET). Supply either a CRTB modified binder or a

CRWET modified binder.

b. Mix Design. Furnish an HMA mixture design for the HMA Crumb rubber mixtures specified, to the Engineer and to the HMA Operations section at Construction Field Services. The submitted designs will be evaluated according to the HMA Production Manual, Procedures for HMA Mix Design Processing. Provide the manufacturers recommended mixing temperature for the rubber modified binder.

c. Recycled Mixtures. The Contractor may substitute Reclaimed Asphalt Pavement (RAP) for a portion of the new materials required to produce HMA mixture. RAP percentage will not exceed Tier 1. The mixture will be designed and produced to meet all of the criteria herein.

d. Materials. Furnish modified Superpave HMA Crumb Rubber mixtures consisting of aggregates of the highest quality available to meet the minimum specifications herein. Furnish a mix design according to the criteria and volumetric properties specified in Table 1 herein.

B.1.6 California

The way our contracts are assembled, use of the bid item number in the bid summary list will set forth the specification requirements. In this case, use of a bid item such as “390138 – Rubberized Hot Mix Asphalt (Open Graded)” will set forth the Standard Specification section (Section 39) that covers the work involved. For this particular recycled material (portion) the use is mandated by the bid item and specification requirements.

B.2 Incentives

B.2.1 Texas

9.6. Progress Payments.

The Engineer will prepare a monthly estimate of the amount of work performed, including materials in place. Payment of the monthly estimate is determined at the Contract Item prices less any withholdings or deductions in accordance with the Contract. Progress payments may be withheld for failure to comply with the Contract.

A. Retainage.

1. Routine Maintenance Contracts.

No retainage will be withheld from routine maintenance Contracts.

2. Construction Contracts.

a. Contracts Without Recycled Materials.

For a Contract not using nonhazardous recycled materials (NRMs) as defined by Item 6, "Control of Materials," and DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines," 5% retainage will be withheld from the total amount approved for payment until the completion and final acceptance.

b. Contracts With Recycled Materials.

For a Contract using NRMs, submit all required documentation before the first monthly progress estimate. For the Contract, 4% retainage will be withheld until the completion and final acceptance.

c. Partial Retainage Release.

(1) Vegetative Establishment and Maintenance, Test and Performance Periods.

For a Contract that provides for a separate vegetative establishment and maintenance, and test and performance periods following the completion of all other construction in the Contract for all work locations, the Department may release a portion of the amount retained provided all other work is completed as determined by the Engineer. Before the release, all submittals and final quantities must be completed and accepted for all other work. An amount sufficient to ensure Contract compliance will be retained.

(2) Final Acceptance.

For a Contract on which recycled materials is used, 50% of the 4% retainage withheld will be released upon final acceptance. For a Contract without recycled materials, 60% of the 5% retainage withheld will be released upon final acceptance.

d. Final Retainage Release.

The remaining retainage will be released after all submittals are received and final quantities have been determined.

B.3 Legislation

B.3.1 Texas

Appropriations Bill

19. Local Government Assistance. The Department of Transportation, pursuant to Texas Transportation Code §201.706, may use funds appropriated by this Act to assist cities with the maintenance of city streets by providing engineering/maintenance expertise on roadway maintenance and when surplus materials are available, the department shall make available the surplus materials to any local government needing such materials. For those cities that adopt or have adopted either a street use fee for maintenance or a specialized fee for street accessibility improvements as part of their local utility fees, the Department is authorized to use funds appropriated by this Act to coordinate its accessibility programs with those cities including providing engineering expertise where possible.

Rider 19- Local Government Assistance
The Department of Transportation, pursuant to Texas Transportation Code §201.706 may use funds appropriated by this act to assist cities with the maintenance of city streets by providing engineering and maintenance expertise on roadway maintenance and when surplus materials are available, the department shall make available the surplus materials to any local government needing such materials.

For those cities that adopt or have adopted either a street use fee for maintenance or a specialized fee for street accessibility improvements as part of their local utility fees, the Department is authorized to coordinate its accessibility programs with those cities including providing engineering expertise where possible.

Charges
Charge numbers to track these programs are:
Segment 72, "COUNTY-A", Function 110 - Materials Provided to Counties

This includes all materials provided to counties in Fiscal Years 2014-2015, based on 43TAC § 29.3, Local Government Assistance Program. We wish to emphasize the importance of placing a record of the material into MSMS and issuing it out of MSMS to the county. It is mandatory that the county number be inserted when the material is issued.

Segment 72, "RIDER19-E", Function 110 - Materials Provided to Cities for Rider 19

This includes all materials provided to the cities as a result of Rider 19, Local Government

Assistance, in the Appropriation Bill (HB 1) for Fiscal Years 2014-2015.

Segment 72, "RIDER19-M", Function 110 – Engineering and Maintenance Expertise to Cities for Rider 19.

This includes all costs associated with providing engineering and maintenance assistance to cities as a result of Rider 19, Local Government Assistance in the Appropriation bill (HB 1) for Fiscal Years 2014-2015.

Appendix C: List of C&D Facilities by Type

*The following table was obtained by the FDEP (Florida Department of Environmental Protection)

Table C1: List of C&D Facilities by Type

District	County	Facility Name	Address	City	Zip	Telephone Number	Facility Type
Central	BREVARD	Cape Canaveral Air Force Station C&D Disposal Facility	1224 Jupiter Street, MS 9125	Patrick AFB	32925	(321) 853-5872	Land Fill
Central	BREVARD	Melbourne Landfill & Recycling Center	3351 Sarno Rd.	Melbourne	32934	(321) 255-6625	Land Fill
Central	INDIAN RIVER	Indian River County SWDD	1325 74th Ave. SW	Vero Beach	32968	(772) 770-5112	Land Fill
Central	LAKE	Diversified Environmental Management	9110 South Grassy Lake Rd	Minneola	34755	(352) 243-2320	Land Fill
Central	LAKE	Lake County Solid Waste Management Facility	13130 County Landfill Rd.	Tavares	32778	(352) 343-3776	Land Fill
Central	LAKE	Mt. Dora Disposal & Fill LLC	3300 SR 46			(407) 402-2802	Land Fill
Central	LAKE	Professional Dirt Service C&D Facility	20804 CR 44-A	Eustis	32727	(352) 589-7000	Land Fill
Central	MARION	Friends Recycling LLC	2350 NW 27th Ave.	Ocala	34475	(352) 266-4852	Land Fill
Central	MARION	Northside Materials Recycling Facility LLC	3805 NE 77th St.	Ocala	34479	(352) 369-5411	Land Fill
Central	MARION	Southside Materials Recycling Facility	4980 SE 92nd Place Rd.	Ocala	34480	(352) 369-5411	Land Fill
Central	MARION	Veolia Cypress Acres Landfill	7424 NE 33rd Ct	Ocala	34479	(352) 629-3500	Land Fill
Central	ORANGE	545 Landfill	8050 Avalon Rd.	Winter Garden	34787	(904) 732-3207	Land Fill
Central	ORANGE	Mid Florida Materials Co. C&D Landfill	3602 Golden Gem Rd.	Plymouth	32768	(451) 886-4879	Land Fill
Central	ORANGE	Pine Ridge C&D Disposal Facility	5400 Rex Rd.	Winter Garden	34787	(813) 786-6807	Land Fill
Central	ORANGE	West Orange Environmental	7706 Avalon Rd.	Winter Garden	34787	(407) 905-0937	Land Fill
Central	ORANGE	Angelo's Recycled Materials-Apopka	2105 Vulcan Rd.	Apopka	32703	(407) 290-8010	MRF
Central	ORANGE	Rocket Blvd. MRF	11273 Rocket Blvd.	Orlando	32824	(904) 732-3207	MRF
Central	OSCEOLA	Bass Road Landfill	750 South Bass Road	Kissimmee	34741	(407) 962-1102	Land Fill
Central	SEMINOLE	Seminole County Landfill	1930 E. Osceola Rd.	Geneva	32732	(407) 665-2251	Land Fill

Table C1, continued

District	County	Facility Name	Address	City	Zip	Telephone Number	Facility Type
Central	VOLUSIA	4 Jays C&D Debris Landfill	425 So. SR 415	Samsula	32168	(386) 860-4355	Land Fill
Central	VOLUSIA	Clyde Morris C&D Site	925 S Clyde Morris Blvd.	Daytona Beach	32115	(386) 671-8673	Land Fill
Central	VOLUSIA	Kirton-Self C&D	1630 Tomoka Farms Rd.	Daytona Beach	32124	(386) 767-3113	Land Fill
Central	VOLUSIA	Samsula Landfill	363 SR 415	New Smyrna	32168	(386) 423-6769	Land Fill
Central	VOLUSIA	GEL Corp	1200 South Leavitt Ave.	Orange City	32763	(386) 775-5385	MRF
Northeast	ALACHUA	County Line Landfill	940 NW 247th Dr.	Newberry	32669	(352) 472-3414	Land Fill
Northeast	ALACHUA	Florence Landfill	3003 SE 15th St.	Gainesville	32641	(352) 375-9919	Land Fill
Northeast	DIXIE	Dixie County Transfer Station and C&D Site	100 Swafford Rd.	Cross City	32628	(352) 498-1432	Transfer Station
Northeast	DUVAL	Jones Road Landfill	3400 Jones Rd.	Jacksonville	32220	(904) 781-2407	Land Fill
Northeast	DUVAL	Old Kings Road Solid Waste, Inc.	PO Box 2089	Jacksonville	32203	(352) 588-4958	Land Fill
Northeast	FLAGLER	Flagler Construction and Demolition Site	2198 CR 13	Bunnell	32110	(386) 437-0960	Land Fill
Northeast	FLAGLER	Flagler County Construction & Demolition Facility	1700 Old Kings Rd. South	Flagler Beach	32136	(386) 313-4049	Land Fill
Northeast	NASSAU	Nassau C&D Landfill	450496 S. R. 200	Callahan	32011	(904) 879-2301	Land Fill
Northeast	ST. JOHNS	Nine Mile Road Landfill	445 International Golf Parkway	St. Augustine	32095	(904) 825-2105	Land Fill
Northeast	SUWANNEE	All South C&D Disposal Facility	10733 68th Path	Live Oak	32060	(386) 364-4432	Land Fill
Northeast	SUWANNEE	Live Oak C&D Landfill, LLC	6897 CR 795	Live Oak	32060	(386) 590-6542	Land Fill
Northwest	BAY	Calvin's C&D Landfill	1741 N Sherman Ave.	Panama City	32405	(850) 785-1503	Land Fill
Northwest	BAY	Demolition Disposal	4632 Pipeline Rd.	Lynn Haven	32444	(850) 747-0833	Land Fill
Northwest	BAY	Hwy. 231 Disposal Facility C&D Landfill	4116 Hwy. 321 North	Panama City	32404	(850) 769-3477	Land Fill
Northwest	BAY	SR 20 C&D Disposal Facility	1310 Redwood Ave.	Panama City	32401	(850) 527-9408	Land Fill
Northwest	BAY	Trash Rolloff Inc. Pit	9208 Campflowers Rd.	Panama City	32409	(850) 277-1001	Land Fill
Northwest	BAY	Trash Rolloff of Bay County Inc	9206 Campflowers Rd.	Panama City	32409	(850) 277-1001	Land Fill
Northwest	BAY	WHR West Bay/Big Wheel	11640 Steelfield Rd.	Panama City	32412	(850) 428-1046	Land Fill

Table C1, continued

District	County	Facility Name	Address	City	Zip	Telephone Number	Facility Type
Northwest	BAY	WRH Lynn Haven/Aztec Environmental	2001 East Hwy 38.	Panama City	32409	(850) 428-1046	Land Fill
Northwest	BAY	WRH Panama City LLC/Sunbelt Environmental Inc.	11901 Sunbelt Drive	Panama City Beach	32413	(850) 428-1046	Land Fill
Northwest	BAY	WRH Southport LLC/Disposal Depot	13111 N. Hwy 77	Panama City		(850) 784-0606	Land Fill
Northwest	BAY	Coyote C&D - Panama City	2101 E. 6th St.	Panama City	32401	(850) 936-9393	Transfer Station
Northwest	CALHOUN	WRH Blountstown Landfill	15888 SW Silas Green Rd.	Blountstown	32424	(850) 428-1046	Land Fill
Northwest	ESCAMBIA	Cerny Road C&D disposal Facility	3223 Milfore Rd.	Pensacola	32526	(850) 969-1328	Land Fill
Northwest	ESCAMBIA	Saufley Landfill, Inc.	5660 Saufley Field Road	Pensacola	32526	(850) 456-4466	Land Fill
Northwest	ESCAMBIA	Group III Asphalt Inc. - Cantonment	55 E. Quintette Rd.	Cantonment	32533	(850) 478-5250	MRF
Northwest	ESCAMBIA	Group III Asphalt, Inc. - Milton	6108 Wastle Road	Milton	32583	(850) 478-5250	MRF
Northwest	LEON	Aenon Church Road C&D Disposal Facility	2320 Aenon Church Road	Tallahassee	32304	(850) 576-7176	Land Fill
Northwest	LEON	Solomon C&D Landfill	8305 Blountstown Hwy.	Tallahassee	32310	(850) 627-8428	Land Fill
Northwest	OKALOOSA	Arena Landfill & Sand, LLC	5105 Arena Road	Crestview	32536	(850) 682-5858	Land Fill
Northwest	OKALOOSA	BHC Point Center	100 Point Center Road	Crestview	32536	(334) 858-6666	Land Fill
Northwest	OKALOOSA	Eglin Air Force Base	Range B-26	Eglin AFB	32542	(850) 882-7672	Land Fill
Northwest	OKALOOSA	WRH Crestview Landfill	3461 Little Silver Rd.	Crestview	32539	(850) 428-1043	Land Fill
Northwest	SANTA ROSA	Coyote- Navarre Landfill	3201 Five Forks Rd.	Navarre	32566	(850) 936-9393	Land Fill
Northwest	SANTA ROSA	Joiner Fill Dirt, Inc.	6070 Stewart St.	Milton	32570	(850) 456-4466	Land Fill
Northwest	SANTA ROSA	Persimmon Hollow C&D Landfill	4751 Persimmon Hollow Rd.	Milton	32583	(850) 554-1936	Land Fill
Northwest	WALTON	Coyote East C&D Disposal	2377 Hwy. 20	Freeport	32439	(850) 936-9393	Land Fill
Northwest	WALTON	Coyote West C&D Disposal Facility	520 Hatcher Cemetery Rd.	Freeport	32439	(850) 936-9393	Land Fill
Northwest	WALTON	WRH Freeport Landfill	2256 Hwy 20 West	Freeport	32439	(850) 428-1046	Land Fill
South	CHARLOTTE	SLD-30301	30301 Zemel Rd.	Punta Gorda	33950	(941) 575-6000	Land Fill
South	CHARLOTTE	Southwest Land Developers C&D Debris & Recycling	30001 Zemel Rd.	Punta Gorda	33955	(941) 637-8345	Land Fill
South	COLLIER	Naples Landfill	3750 White Lake Blvd.	Naples	34117	(239) 455-8062	Land Fill

Table C1, continued

District	County	Facility Name	Address	City	Zip	Telephone Number	Facility Type
South	COLLIER	Delta Recycling Naples	5801 Yahl Street	Naples	34109	(239) 445-8062	MRF
South	COLLIER	Pro-Disposal Naples	3715 Progress Ave	Naples	34104	(239) 643-6602	MRF
South	HIGHLANDS	Highlands County Solid Waste Management Center	12700 Arbuckle Creek Road	Sebring	33870	(863) 655-6483	Land Fill
South	LEE	Pro Disposal Ft. Myers	16801 Stock Court	Ft. Myers	33912	(239) 643-6602	MRF
South	LEE	USA Recycling Center	16711 Gator Road	Fort Myers	33912	(239) 489-0505	MRF
South	MONROE	Rockland Recycling Center	US Hwy1 @ MM9	Rockland Key	33045	(305) 296-8297	Transfer Station
Southeast	BROWARD	Central Disposal	2700 NW 48th St.	Pompano Beach	33073	(954) 984-2065	Land Fill
Southeast	BROWARD	Eco Waste Transfer & Recycling	1899 SW 31 Ave.	Pembroke Lakes	33309	(954) 989-9715	MRF
Southeast	BROWARD	Sun Recycling #1	2241 NW 15th Ct.	Pompano Beach	33069	(561) 582-6688	MRF
Southeast	BROWARD	Sun Recycling #2	2281 NW 16th Street	Pompano Beach	33069	(561) 582-6688	MRF
Southeast	BROWARD	Sun Recycling #3	3251 SW 26th Terrace	Dania Beach	33312	(561) 582-6688	MRF
Southeast	BROWARD	Delta Recycling Davie	3250 S. W. 50th Ave.	Davie	33314	(954) 452-4233	Transfer Station
Southeast	BROWARD	Sun Recycling #7	1815 S. Powerlind Rd.	Deerfield	33442	(561) 582-6688	Transfer Station
Southeast	BROWARD	Uhel Polly Hauling, Inc.	2201 N. W. 16th St.	Pompano Beach	33069	(954) 971-3870	Transfer Station
Southeast	DADE	Medley Landfill & Recycling Center	9350 NW 89th Ave.	Medley	33178	(305) 883-7670	Land Fill
Southeast	DADE	American Environmental Recycling	10001 Southwest 240 street	Miami	33174	(305) 232-2340	MRF
Southeast	DADE	Florida Wood Recycling	9651 NW 89th Ave.	Medley	33178	(305) 805-0033	MRF
Southeast	DADE	Delta Recycling Hialeah Transfer Station	5000 NW 37 Ave.	Miami	33142	(305) 634-7138	Transfer Station
Southeast	DADE	Delta Recycling Homestead	11695 SW 328th St.	Homestead	33033	(305) 453-0788	Transfer Station
Southeast	DADE	Sun Recycling #6	2000 N. Miami Ave.	Miami	33127	(561) 582-6688	Transfer Station
Southeast	MARTIN	Waste Management of Palm City	9001 SW Busch Street	Palm City	34990	(772) 545-1314	Transfer Station
Southeast	PALM BEACH	Atlas Lox Inc.	15400 Loxahatchee Rd.	Parkland	33076	(954) 543-9800	MRF
Southeast	PALM BEACH	Palm City Transfer & Recycling, Inc.	1025 26th Street	West Palm Beach	33407	(561) 650-0801	MRF
Southeast	PALM BEACH	Sun Recycling #4	6911 Wallis Road	West Palm Beach	33143	(561) 202-2456	MRF

Table C1, continued

District	County	Facility Name	Address	City	Zip	Telephone Number	Facility Type
Southeast	PALM BEACH	Delta Recycling Riviera Beach	7905 Barbour Rd.	Riviera Beach	33407	(954) 444-5471	Transfer Station
Southeast	PALM BEACH	Delta Recycling Tall Pines	411 Tall Pines Rd.	West Palm Beach	33412	(954) 984-2022	Transfer Station
Southeast	PALM BEACH	Sun Recycling #5	790 Hillbrath Rd.	Lantana	32463	(561) 202-2456	Transfer Station
Southeast	ST. LUCIE	SLC Solid Waste Baling & Recycling	6120 Caldes Cutoff Rd.	Ft. Pierce	34981	(772) 462-1631	Land Fill
Southeast	ST. LUCIE	East Coast Recycling	4880 Glades Cut-Off Rd.	Fort Pierce	34981	(561) 461-5833	MRF
Southwest	CITRUS	Citrus Sand & Debris II Inc.	3890 W. Grover Cleveland Blvd.	Homosassa	34446	(352) 746-7713	Land Fill
Southwest	CITRUS	Citrus Sand & Debris, Inc.	1590 Quarterback Terrace	Crystal River	34423	(352) 746-7713	Land Fill
Southwest	CITRUS	R.I.P., Inc.	5355 W. Grover Cleveland	Homosassa	34446	(312) 942-0042	Land Fill
Southwest	CITRUS	Sand Land of Florida Ent. Inc.	5920 N Florida Ave.	Hernando	34445	(352) 489-6912	Land Fill
Southwest	DESOTO	Hwy 70 Arcadia Landfill	Hwy 70 East	Arcadia		(813) 781-6848	Land Fill
Southwest	HERNANDO	Hernando County Waste	14450 Landfill Rd.	Brooksville	34614	(352) 754-4112	Land Fill
Southwest	HERNANDO	Sunshine Grove Road C&D Landfill-Phase I	9450 Sunshine Grove Rd.	Brooksville	34616	(352) 179-0486	Land Fill
Southwest	HILLSBOROUGH	Coniglio C&D Debris Landfill	11981 N. Williams Rd.	Thonotosassa	38592	(813) 986-2097	Land Fill
Southwest	HILLSBOROUGH	Sun Country Materials Management	11457 CR 672	Balm	33598	(813) 248-3802	Land Fill
Southwest	HILLSBOROUGH	Williams Road Recovery Facility	7711 Williams Rd.	Seffner	33584	(813) 623-1177	Land Fill
Southwest	HILLSBOROUGH	Metro Recycling	2702 E 2nd Ave.	Tampa	33605	(831) 248-6435	MRF
Southwest	HILLSBOROUGH	Tampa Transfer MRF	3518 4th Street	Tampa	33605	(813) 786-6807	MRF
Southwest	MANATEE	63rd Avenue Transfer Station	1805 63rd Avenue	Bradenton	34203	(813) 781-6848	Transfer Station
Southwest	PASCO	Coastal Landfill Disposal of FL	11416 Houston Ave.	Hudson	34667	(770) 433-2484	Land Fill
Southwest	PASCO	Pasco Lakes, Inc.	9344 Old Pasco Rd.	Wesley Chapel	33544	(352) 588-4958	Land Fill
Southwest	PINELLAS	Angelo's Recycled Materials-Largo	1755 20th Ave. SE	Largo	33771	(727) 581-1544	MRF
Southwest	PINELLAS	Pinellas Transfer	12059 40th Street North	Clearwater	33762	(813) 786-6807	MRF
Southwest	PINELLAS	Sonny Glassbrenner, Inc.	3741 126th Ave. N	Clearwater	33762	(727) 573-1110	MRF
Southwest	POLK	Northeast (Site204) C&D Debris Disposal	10 environmental Loop	Winter Haven	33880	(863) 284-4319	Land Fill

Table C1, continued

District	County	Facility Name	Address	City	Zip	Telephone Number	Facility Type
Southwest	POLK	Southeast (Site 203) C&D Debris Disposal Facility	10 Environmental Loop	Winter Haven	33880	(863) 284-4319	Land Fill
Southwest	POLK	Waste Corp of Central Florida - Ft. Meade	3400 Highway 17 North	Ft. Meade	33841	(863) 285-8393	Land Fill
Southwest	SARASOTA	Central County Solid Waste Disposal Complex	4000 Knights Trail Rd.	Nokomis	34275	(941) 650-2689	MRF
Southwest	SARASOTA	Recycle America of Sarasota	3100 N Washington Blvd.	Sarasota	34234	(941) 355-9230	Transfer Station
Southwest	SARASOTA	Sun Coast Sanitation	3971 Carmichael Ave.	Sarasota,	34234	(941) 359-8803	Transfer Station
Southwest	SUMTER	446-A Landfill Facility LLC	CR466A Sumter/Lake County Line	Okahumpka	34762	(352) 267-0197	Land Fill
Southwest	SUMTER	Recycling & Solid Waste	453 CR 489	Lake Panasoffkee	33538	(352) 568-0999	Land Fill

Appendix D: Summary of the Calculation of Total Concrete and Asphalt Waste from FDOT in 2012

RAP Milling and Concrete Demolition Work in Florida in 2012									
Item	**Description**	**Areas Total**	**Unit**	**SY**	**CY/SF**	**Thickness (yd.)**	**Volume (CY)**	**Density (lb/CY)**	**Weight (TNs)**
0110 3	REMOVAL OF EXISTING STRUCTURE	194,658.40	SF	21,628.71	0.11	-	21412.42	3,780	40,469.48
0110 4	REMOVAL OF EXISTING CONCRETE PAVEMENT	213,519.89	SY	213,519.89	-	0.22	47,448.86	3,780	89,678.35
0327 70 1	MILLING EXIST ASPH PAVT, 1" AVG DEPTH	1,464,732.77	SY	1,464,732.77	-	0.03	40,687.02	3,500	71,202.29
0327 70 2	MILLING EXIST ASPH PAVT, 3 1/2" AVG DEPTH	476,920.00	SY	476,920.00	-	0.1	46,367.22	3,500	81,142.64
0327 70 3	MILLING EXIST ASPH PAVT, 4 1/2" AVG DEPTH	9,366.00	SY	9,366.00	-	0.13	1,170.75	3,500	2,048.81
0327 70 4	MILLING EXIST ASPH PAVT, 3" AVG DEPTH	1,066,120.30	SY	1,066,120.30	-	0.08	88,843.36	3,500	155,475.88
0327 70 5	MILLING EXIST ASPH PAVT, 2" AVG DEPTH	2,385,743.63	SY	2,385,743.63	-	0.06	132,541.31	3,500	231,947.30
0327 70 6	MILLING EXIST ASPH PAVT, 1 1/2" AVG DEPTH	3,165,687.65	SY	3,165,687.65	-	0.04	131,903.65	3,500	230,831.39
0327 70 7	MILLING EXIST ASPH PAVT, 4" AVG DEPTH	95,680.00	SY	95,680.00	-	0.11	10,631.11	3,500	18,604.44
0327 70 8	MILLING EXIST ASPH PAVT, 2 1/2" AVG DEPTH	2,147,567.50	SY	2,147,567.50	-	0.07	149,136.63	3,500	260,989.11
0327 70 9	MILLING EXIST ASPH PAVT,5 1/4" AVG DEPTH	1,915.00	SY	1,915.00	-	0.15	279.27	3,500	488.72
0327 70 10	MILLING EXIST ASPH PAVT, 5" AVG DEPTH	11,647.00	SY	11,647.00	-	0.14	1,617.64	3,500	2,830.87
0327 70 11	MILLING EXIST ASPH PAVT, 2 1/4" AVG DEPTH	1,626,121.00	SY	1,626,121.00	-	0.06	101,632.56	3,500	177,856.98
0327 70 12	MILLING EXIST ASPH PAVT, 1 1/4" AVG DEPTH	63,998.90	SY	63,998.90	-	0.03	2,222.18	3,500	3,888.82
0327 70 13	MILLING EXIST ASPH PAVT, 1 3/4" AVG DEPTH	736,896.50	SY	736,896.50	-	0.05	35,821.36	3,500	62,687.38
0327 70 14	MILLING EXIST ASPH PAVT,6 1/2" AVG DEPTH	29,216.00	SY	29,216.00	-	0.18	5,275.11	3,500	9,231.44
0327 70 15	MILLING EXIST ASPH PAVT, 2 3/4" AVG DEPTH	1,879,430.50	SY	1,879,430.50	-	0.08	143,567.61	3,500	251,243.31
0327 70 16	MILLING EXIST ASPH PAVT, 1/2" AVG DEPTH	292,866.40	SY	292,866.40	-	0.01	4,067.59	3,500	7,118.28
0327 70 17	MILLING EXIST ASPH PAVT, 3 1/4" AVG DEPTH	771,440.00	SY	771,440.00	-	0.09	69,643.89	3,500	121,876.81
0327 70 19	MILLING EXIST ASPH PAVT, 3/4" AVG DEPTH	775,563.30	SY	775,563.30	-	0.02	16,157.57	3,500	28,275.75
0327 70 20	MILLING EXIST ASPH PAVT, 3 3/4" AVG DEPTH	53,066.60	SY	53,066.60	-	0.1	5,527.77	3,500	9,673.60
0327 70 22	MILLING EXIST ASPH PAVT, 4 1/4" AVG DEPTH	259,252.00	SY	259,252.00	-	0.12	30,606.14	3,500	53,560.74
0327 70 26	MILLING EXIST ASPH PAVT, 4 3/4" AVG DEPTH	42,175.00	SY	42,175.00	-	0.13	5,564.76	3,500	9,738.32
0327 70 28	MILLING EXIST ASPH PAVT, 6 3/4" AVG DEPTH	136	SY	136	-	0.19	25.5	3,500	44.63

Appendix E: Cost Models

		Mixed Materials
A	Cubic Yards	88
B	Tons	22
C	# Loads	4
D	Pull Charge	$225
E	**Haul Subtotal 1**	**$900.00**
F	Value of Goods Sold	$0
G	Diversion Charge	$15
H	**Value of Subtotal 2 (column F or G*B)**	**$330**
I	Landfill Tipping Fee	$7
J	**Value of Subtotal 3 (column A*I)**	**$616**
K	**Total Cost of Diverting Materials (E+H)**	**$1,230.00**
L	**Total Cost of Landfill Disposal (E+J)**	**$1,516.00**

		Wood
A	Cubic Yards	67
B	Tons	6
C	# Loads	3
D	Pull Charge	$225
E	**Haul Subtotal 1**	**$675.00**
F	Value of Goods Sold	$0
G	Diversion Charge	$0
H	**Value of Subtotal 2 (column F or G*B)**	**$0**
I	Landfill Tipping Fee	$7
J	**Value of Subtotal 3 (column A*I)**	**$469**
K	**Total Cost of Diverting Materials (E+H)**	**$675.00**
L	**Total Cost of Landfill Disposal (E+J)**	**$1,144.00**

		Metals
A	Cubic Yards	54
B	Tons	6
C	# Loads	2.7
D	Pull Charge	$225
E	**Haul Subtotal 1**	**$607.50**
F	Value of Goods Sold (per ton)	$220
G	Diversion Charge	$0
H	**Value of Subtotal 2 (column F or G*B)**	**$1,320**
I	Landfill Tipping Fee (cubic yard)	$7
J	**Value of Subtotal 3 (column A*I)**	**$378**
K	**Total Cost of Diverting Materials (E-H)**	**+$729**
L	**Total Cost of Landfill Disposal (E+J)**	**$985.50**

		Concrete
A	Cubic Yards	117
B	Tons	50
C	# Loads	6
D	Pull Charge	$225
E	**Haul Subtotal 1**	**$675**
F	Value of Goods Sold (per ton)	$0
G	Diversion Charge	$0
H	**Value of Subtotal 2 (column F or G*B)**	**$0**
I	Landfill Tipping Fee	$7
J	**Value of Subtotal 3 (column A*I)**	**$819**
K	**Total Cost of Diverting Materials (E+H)**	**$1360**
L	**Total Cost of Landfill Disposal (E+J)**	**$1,494**

Summary of RAP and RCA Produced in 2012		
	Volume (CY)	**Weight (TNs)**
Concrete	68,861.28	137,147.83
Asphalt	1,023,290.01	1,790,757.51
Total	**1,073,118.03**	**1,884,932.47**

Appendix F: Focus Group Participants

1. Candice Agosto, Division Manager,
   Transcor Recycling LLC

2. Felipe Jaramillo, PE, DBIA, Alternative Contracts Manager
   Ajax Paving Industries of Florida, LLC

3. Greg Moro, Florida Operations Manager,
   Independence Recycling of Florida Inc.

4. Scott Renfroe, Manager
   Florida Concrete Recycling

5. Larry Ritchie, P.E,
   FDOT Construction Office
   (Provided consolidated comments from Construction Office and Alternative Contracting Office)

6. Tony Williams, V.P.
   Anderson Columbia Co., Inc.