February

Glass Cullet

This packet provides information about how and why to use recycled glass in roadway construction and maintenance projects.

Research Summary	"Use of Glass Cullet in Roadway Construction"
Case Study #1	Glass in Flexible Base, City of Devine, Texas
Case Study #2	Glass in Flexible Base, TxDOT Abilene District
Case Study #3	Glass as Pipe Bedding, TxDOT Beaumont District
TxDOT Experience	Summary of TxDOT experience using glass cullet in various applications.
Material Processors	Map and table listing companies that process mixed glass cullet.
Specifications	TxDOT's special provisions allowing the use of glass cullet in: Embankments (Item 132), Flexible Base (Item 247), Asphalt Antistripping Agents (Item 301), Excavation and Backfill for Structures (Item 400), Retaining Wall (Item 423), Pipe Underdrains (Item 556) and Open Graded Base Course.

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Material Brief

Successful recycling programs have produced large quantities of glass in many parts of the country. Glass packaging—bottles and jars which held food, beverages or toiletries—is the primary source for recycled glass. It is soda lime glass, which is composed of sand, soda ash and limestone.

Waste glass constitutes approximately seven percent of the 200 million tons of municipal solid waste generated annually in the United States (Cosentino, 1995). Nearly 10 million tons of glass are deposited in our nation's landfills every year. Washington D.C.-based Glass Packaging Institute (GPI) found that an estimated 35 percent (3.3 million tons) of all glass containers

sold in the United States were recycled in 1997. Texas collects approximately 100,000 tons each year, an estimated 10 percent of the potential amount.

Glass cullet is produced from crushing waste glass collected in municipal and industrial waste streams to a uniform size. Currently, it is primarily used in new glass container manufacturing. Secondary applications include fiberglass insulation, roadbase and highway reflectors, and TxDOT is finding ways to use it in roadway construction.

Using cullet in glassmaking saves energy and reduces costs, but it also has limitations. Color-sorting and transporting cullet can be costly. However, crushed glass does not need to be sorted for use in roadway materials.

The use of crushed glass can extend landfill life, lessen our dependence upon virgin materials and ensure highway durability.

Overview

The possibility of using mixed color glass cullet in roadway construction avoids the expense of a sorting process and offers an attractive alternative to aggregate in parts of the state where aggregate sources are scarce and glass cullet is economically priced. Professionals indicate that a market for color-mixed waste glass could significantly increase glass-collection efforts in recycling programs.

Texas Tech University evaluated the use of glass in roadways, and cullet appears to be an excellent supplement or replacement for gravel in many construction applications. Its benefits from an engineering standpoint include permeability, good compaction characteristics and compatibility with conventional construction equipment (Nash, 1995).

Glass cullet can be competitive in price or less expensive than utilizing conventional aggregates. By diverting even a small portion of the current amount of collected glass to a recycled application, we can stretch the useful life of these disposal sites. Furthermore, no appreciable environmental impact, including leaching, was detected in the Texas Tech study.

Glass has been approved as an aggregate substitute by many entities. For example, Caltrans allows glass in base and subbase, Connecticut in embankments, New Hampshire in aggregate and base course, Pennsylvania as pipe backfill and embankment material and Washington allows up to 15 percent glass in most aggregate locations. The National Standard Plumbing Code even allows glass cullet as storm drain bedding.

Texas has not developed specifications for glasphalt, which is an asphalt containing recycled glass. However, other states have demonstrated its potential, learning that it is best not to incorporate too much glass because of its smooth surface texture and the associated risk of stripping. Mixes containing chemical and hydrated lime anti-stripping additives appear to be acceptable using up to 15 percent glass.

One of the concerns raised regarding the use of cullet mixes in roadway construction is the ability of cullet to withstand repeated traffic loads without breakdown (Shin, 1994). They performed laboratory repeated load testing on glass cullet specimens, and compared the resilient modulus over the first 1,000 cycles for glass cullet and conventional crushed rock. The cullet samples, like crushed rock, did not show appreciable changes in the modulus value. The same study also revealed that compaction curves tend to become flatter as cullet content increases, possibly implying that maximum dry density is relatively insensitive with respect to moisture, which may prove useful in construction during wet weather.

Research Summary

Use of Glass Cullet in Roadway Construction

Problem Statement

Successful recycling collection programs have produced large quantities of broken glass, or cullet, in many parts of the country. Glass cullet is primarily reused to manufacture new glass containers.

Using cullet in glassmaking saves energy and reduces costs. But using cullet also has limitations, primarily due to the need to avoid color contamination and to the cost of transportation. Supplying cullet to furnace-ready specifications requires expensive color sorting, and because of its relative high density, glass cullet is expensive to transport long distances.

Using glass cullet in roadway construction would eliminate the need for expensive sorting and offers an opportunity to use glass cullet as aggregate in parts of the state where aggregate sources are scarce.

Objectives

The Texas Tech University College of Engineering conducted study 0-1331, "Use Of Glass Cullet In Roadway Construction," for TxDOT, the Federal Highway Administration (FHWA) and the Texas Natural Resource Conservation Commission (TNRCC). The researchers were to identify sound engineering and environmental uses of glass cullet in roadway construction and maintenance projects, and develop specifications for each successful use of glass cullet evaluated based on current TxDOT specifications.

Procedures

Specifications for using glass cullet in roadway construction were developed through the following three phases of study:

1. Literature review and identification of available sources and suppliers, including:
   a. A recommendation of which glass cullet uses appear the most feasible and promising.
   b. Potential disadvantages or obstacles to these uses.
   c. Potential effects on future recyclability.
   d. Limited economic analysis comparing the use of glass cullet with currently utilized materials for the selected applications.
   e. A description of available sources and suppliers in Texas.

2. Laboratory testing was conducted to provide information not available from the literature search or to assure the accuracy of information found. Testing focused on problem areas identified by other researchers.

3. Specifications were developed for each successful use of glass cullet evaluated in the course of this study, following TxDOT's current specification formats and requirements.

Findings

The economic viability of glass recycling for highway construction depends upon the market situation in a given area. Highway professionals with experience using glass cullet and industry experts in the glass recycling industry indicated that if there was a market for glass cullet in the highway industry, it would be economically competitive with other materials in major metropolitan areas and their surrounding vicinities. These professionals also indicated that a market for color-mixed waste glass could significantly increase glass-collection efforts in recycling programs.

Other DOTs' specifications indicate there are a variety of uses for glass cullet, ranging from asphalt concrete to drainage backfill.

In general, using glass cullet in asphalt concrete is not considered as attractive an option as other uses due to problems associated with asphalt stripping in moist conditions. The use of glass cullet in portland cement concrete is not feasible due to the high levels of alkali-silica reactivity associated with it. This problem is considered to be particularly acute with fine cullet.

Implementation

This study and others have concluded:

1. From an engineering standpoint, cullet appears to be an excellent supplement or replacement for gravel in many construction applications.
2. There has been no appreciable environmental impact when cullet has been tested for harmful contaminants and for potential for leaching over time.
3. Since glass contains silica rather than crystalline silica, it does not have the health risks associated with natural sand.
4. In many cases, and depending on local conditions, using glass can be cost-competitive or less expensive than using conventional aggregates.

Based on available information, from an engineering standpoint, glass cullet is suitable for a variety of uses. The economic feasibility varies depending on the locale and availability of glass in large quantities.

Specifications were developed for the following applications:

TxDOT Item No.	Application	Percentage of Glass Cullet Permitted
132	Embankments	Shall not exceed 20% by weight of the total mix.
247	Flexible base (Type D)	Shall not exceed 20% by weight of the total mix.
301	Asphalt anti-stripping agents	When cullet is used as an aggregate in asphalt-stabilized bases, lime and some liquid anti-stripping agents may not perform adequately.
345	Asphalt-stabilized base	Shall not exceed 5% of the total weight of the aggregate.
400	Excavation and backfill for structures	a.) Utility bedding material may comprise up to 100%. b.) Backfill that will support any portion of roadbed or embankment shall include less than 20%. c.) Backfill that does not support any portion of the roadbed or embankment may include up to 100%.
423	Retaining wall	Structural backfill limited to maximum of 20%. Non-structural backfill up to 100%.
556	Pipe underdrains	Up to 100%.
Other	Open-graded base courses	The use of cullet in this application shall be governed by Item 345, “Asphalt-stabilized base.” Not to exceed 5%.

To obtain a copy of this report, please contact the TxDOT Construction Division–Research Librarian at (512) 465-7644.

*The contents of this summary are reported in detail in Texas Tech University College of Engineering Research Reports 0-1331-1 and 0-1331-3, “Use Of Glass Cullet In Roadway Construction,” Phillip T. Nash, Priyantha Jayawickrama, Richard W. Tock, Sanjaya Senadheera, Krishnan Viswanathan and Binli Woolverton, August 1995. This summary does not necessarily reflect the official views of the FHWA, TNRCC or TxDOT.

NOTE:

As a part of a research study being conducted by TxDOT under the FHWA Priority Technology Program (PTP), three test projects were constructed in Texas during 1996 and 1997. The performance of these recycled materials is being monitored by Texas Tech University. A brief description of these test projects is included in the case studies.

Case Study #1

Glass in Flexible Base, City of Devine, Texas

Project Overview:

This project was designed and managed by a private firm on behalf of the City of Devine. TxDOT assisted because this was the first test project to use the draft specifications developed by Texas Tech through TxDOT research. The project was underwritten by the Alamo Area Council of Government.

This test project involved the rehabilitation of Colonial Parkway and North Teal Drive in the city of Devine. Construction was done in July 1996, and it involved reworking existing surface and base layers as the subbase for the new pavement. A 80/20 blend of crushed limestone and glass cullet was used to construct the flexible base, and hot mix asphalt with limestone rock asphalt (LRA) aggregate was used in the surface layer.

Vista Fibers of San Antonio supplied 440 tons of waste glass for the project. The glass was stockpiled at Vulan Materials–1604 Plant in San Antonio. Prior to construction, the glass and limestone were blended in the proper ratio and crushed.

Specifications:

TxDOT Item 247, Grade 6 Materials

The flexible base material shall be crushed limestone to meet the requirements herein and shall consist of durable coarse aggregate, glass cullet and binding materials.

Physical Requirements

A. Type D

B. Master Grading

Sieve	% Retained
3/4"	0
5/8"	0-15
3/8"	15-40
No. 4	35-65
No. 40	70-90

Maximum Liquid Limit–30

Maximum Plasticity Index–12

C. Additives: 20 percent by weight of glass cullet

Testing of flexible base materials shall be in accordance with the following standard laboratory test procedures.

Preparation for Soil

Constants and Sieve Analysis	THD Tex-101-E
Liquid Limit	THD Tex-104-E
Plastic Limit	THD Tex-105-E
Plasticity Index	THD Tex-106-E
Linear Shrinkage	THD Tex-107-E
Sieve Analysis	THD Tex-110-E
Los Angeles Abrasion	ASTM C 131-66 (Grad. A)

Test Data:

Prior to Construction

Test	Existing Subgrade	Existing Salvaged Base	Stockpile Mixed with 20% Cullet	Specification Requirements
Sieve Analysis	Percent Retained	Percent Retained	Percent Retained	Percent Retained
1 3/4"	2	0	0	0
7/8"	6	3	0	-
5/8"	-	-	-	0-15
3/8"	14	12	30	15-40
No. 4	21	19	53	35-65
No. 40	35	33	83	70-90
Atterburg Limit				
Liquid Limit	25	27	23	30
Plastic Limit	14	27	-	-
Plasticity Index	11	0	10	12
Compaction Ratio				
Dry Density	125.0 pcf	123.5 pcf	136.3 pcf	
Opt. Moisture Unit	9.5 %	10 %	7.1 %	
Weight	-	-	100.6 pcf	
Triaxial Class	2.9	3.6		
Confining Pressure/ Failure Stress	0 psi/27 psi 15 psi/102 psi	0 psi/25 psi 15 psi/90 psi		

During the Compaction Operation

Highway	Station	Lab Density (pcf)	Lab Moisture (percent)	Field Density (pcf)	Field Moisture (percent)
Teel Street	21+00	136.3	7.1	142.6	3.7
Teel Street	15+00	136.3	7.1	136.1	3.9
Colonial Drive	12+00	136.3	7.1	142.5	3.1
Colonial Drive	12+50	136.3	7.1	144.9	3.6

Constructed Pavement Base

Test	Test Results	
Sieve Analysis	Sieve Size	% Retained
	1 3/4"	0
	7/8"	1
	3/8"	34
	No. 4	57
	No. 40	81
Compaction	Dry Density : 137.1 pcf Optimum Moisture Content: 5.9%	

Constructed HMAC Pavement Surface

Sample Location	Percent Air Voids	Core Density (pcf)	Nuclear Density (pcf)
Colonial Parkway: Between Indian Rd. and J.T. Moore Rd.	18.8	119.6	135.7
Colonial Parkway: Between J.T. Moore Rd. and Gutierrez Rd.	18.4	120.3	140.3
Colonial Parkway: Between Gutierrez Rd. and Oakridge Rd.	16.7	122.8	142.8
Teel Road	14.5	126.0	137.0

Results:

The Texas Tech University research team entrusted with the task of monitoring these test projects made several visits to this project.

This test project showed premature alligator cracking. These two roads are residential streets. However, investigations revealed that due to a train accident on US 87, a bridge was damaged, and the resulting temporary closure of US 87 resulted in a significant increase of heavy truck traffic on the two streets. City officials estimated this increase in heavy traffic to be three to four times greater than the design traffic. Once US 87 was opened, the rate of deterioration on Colonial Parkway and North Teal Drive showed a significant decrease, and subsequent visits to the site as late as August 1998 showed that no further significant deterioration had taken place. These observations were supported by measurement of rutting using the TxDOT rut bar measurements. Therefore, the reason for premature distress can possibly be attributed to unusually high and heavy traffic.

Pavement Ride Quality

The pavement ride quality on the Devine glass cullet project was measured using the TxDOT profiler/rut bar equipment to produce a "Ride Score" and an "International Roughness Index."

The ride score is assigned to pavement based on a scale of 1 to 5, with 5 indicating a pavement with perfect ride quality. These values indicate that the given pavements have ride qualities in the low to medium range after one year of service. This indicates a rate of deterioration that is typically rated as high. Based on what has been observed in the field, this rapid deterioration is the result of unusually high levels of heavy vehicles on the road due to highway detours. This project is still being monitored.

Ride Score Values

	Left Wheel Path	Right Wheel Path
Ride Score Values (measured at every 0.1 mile)	3.7, 3.5, 3.6, 3.4, 3.0, 2.8, 2.7, 2.7, 3.3, 3.1, 3.4, 3.2	3.3, 3.2, 2.8, 2.5, 2.9, 3.0, 2.4, 2.2
Average	3.2	2.8
Standard Deviation	0.34	0.39

The International Roughness Index (IRI) was developed by the World Bank in an effort to provide consistent data about pavement roughness. The IRI is an objective and consistent measure of pavement condition which was chosen as the FHWA Highway Planning and Monitoring System (HPMS) standard reference roughness index to provide more consistency among states. FHWA also directed all states to report pavement roughness data by IRI for all paved, rural arterials and urban freeways and expressways, including interstates, beginning in 1989.

International Roughness Index

	Left Wheel Path	Right Wheel Path
International Roughness Index (measured at every 0.1 mile)	1.45, 1.94, 1.97, 2.55, 1.63, 2.06, 2.45, 2.92, 2.49, 3.55, 3.23, 2.85, 3.18, 2.62, 1.85, 2.10, 1.95, 2.87, 2.18, 3.03	1.63, 1.89, 1.51, 1.43, 1.59, 1.66, 2.06, 2.02, 2.42, 2.16, 1.85, 1.83, 1.86, 1.93, 2.05, 2.19, 1.76, 3.02, 1.78, 3.26
Average	2.44	1.99
Standard Deviation	0.54	0.46

Case Study #2

Glass in Flexible Base, TxDOT Abilene District

Project Overview:

The test project is on Antilley Road, a city street in front of Wiley High School. Glass cullet was mixed with conventional crushed limestone to form the flexible base at the job site. The project involved widening a two-lane road to a five-lane road including a turn lane and was constructed in May 1997.

Construction involved spreading 12 inches of crushed limestone and glass cullet. A pavement material recycler mixed the two materials, and then the blend was compacted. A 1.5 inch-thick hot mix asphalt concrete surface layer was placed on top of the flexible base layer.

The eastern section of the road used a 10 percent glass cullet while the western section used a 15 percent. Each section is 750 feet long and 12 feet wide. This construction project used 240 tons of glass collected by the city of Abilene over a one-year period. Pine Street Salvage, a local salvage company, provided 75 percent of the glass while Dyess Air Force Base provided the remaining 25 percent.

TxDOT collected and transported the glass from Pine Street Salvage to Dyess air base where the glass was crushed into cullet.

Dyess air base also crushed the glass for this project at a cost of $9 per ton. This cost is in line with industry standards of $7 to $12 per ton for processing glass as aggregate. It took approximately 120 hours to crush the 240 tons of glass.

Specifications:

Specifications were the same as for the City of Devine project. Only 10 percent and 15 percent glass mixes were used.

Test Data:

Test	Limestone	Limestone with 10 % Glass	Limestone with 15% Glass
Sieve Analysis	Percent Retained	Percent Retained	Percent Retained
1 3/4"	0	0	0
1"	12	17	17
7/8"	17	21	21
1/2"	34	44	44
3/8"	39	53	53
No. 4	55	68	68
No. 10	68	74	74
No. 40	81	84	84
Atterburg Limit			
Liquid Limit	22.2	30.2	23.5
Plasticity Index	7.1	12.8	7.0
Compaction Ratio			
Dry Density	134.0 pcf	136.8 pcf	135.4 pcf
Opt. Moisture	7.8 %	7.3 %	6.3 %
WBM Value and Percent Increase	19 and 13	16 and 7	16 and 7

Results:

This project is performing well. Detailed test data are not available at this time.

The City of Abilene was very pleased with the results of this demonstration project and has since purchased its own glass crushing equipment. Abilene now crushes glass from its local dropoff facilities and takes glass from sur-rounding communities. The crushed glass is being used in City of Abilene road construction projects.

Case Study #3

Glass as Pipe Bedding, TxDOT Beaumont District

Project Overview:

The project site is located at the intersection of SH 62 and FM 105 in Orange County, near the Orange County Airport. In this project, glass cullet was used as bedding material around two culvert pipes. This project was constructed in November 1997.

Specifications:

Glass was crushed to quarter-inch pieces or smaller to be used as bedding material.

Test Data:

Detailed test data is not available at this time.

Results:

The test project is performing satisfactorily at this point.

TxDOT Experience

Glass

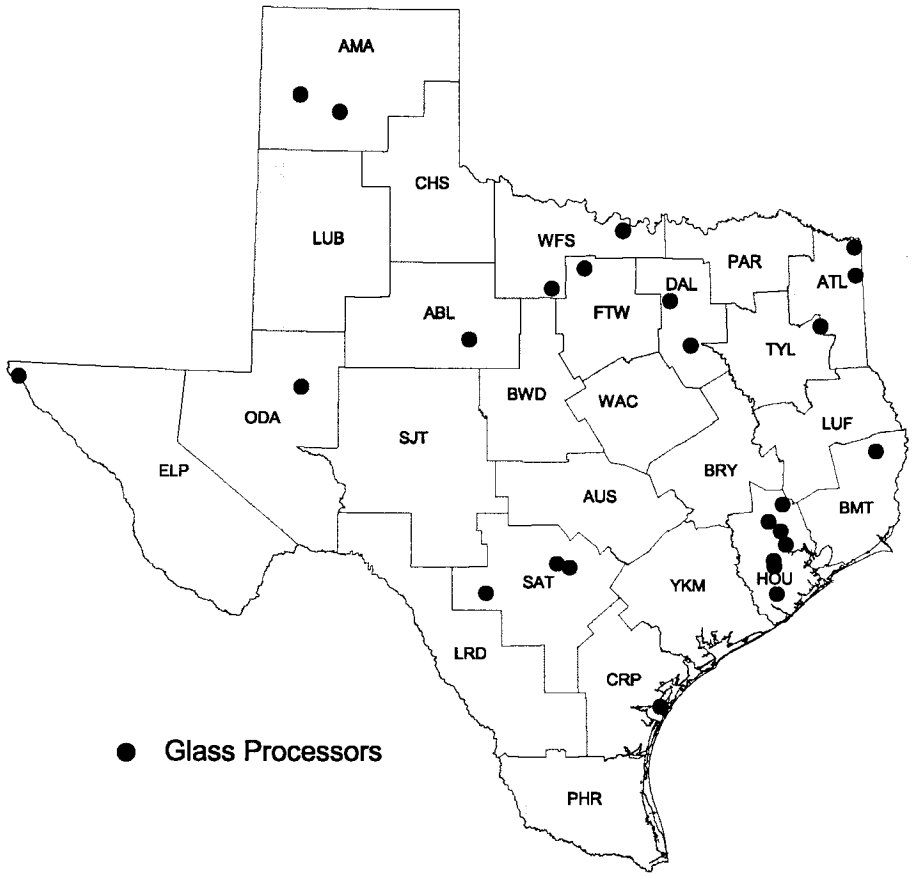
This table provides information about TxDOT's experience using glass cullet in three different construction applications, including base and subbase, embankments and backfill, and asphaltic concrete paving.

District Name	Construction Application	Results	Installed	Specification	Location	Additional Comments
Abilene	Paving Materials - Base/Subbase	Good	1997		Antilley Rd	2 test sections, one using 10% the other 15% glass
Beaumont	Embankments and Backfill	Good	1997		SH 62/FM 105	used 100% glass as driveway pipe fill material
Bryan	Paving Materials - Asphaltic Concrete	Unknown	1996		Various	
Bryan	Paving Materials - Asphaltic Concrete	Good	1986	340-003-999	US 290 W	

Material Processors

The map and table provide information on companies that have expressed an ability and/or willingness to crush glass to meet pending TxDOT specifications.

Andrew Andrasi, in his master's report titled *" Identifying Sources of Traditional and Alternative Road Building Materials for Texas Using GIS,"* performed research on non-hazardous recycled material processors (Andrasi, 1998).



Companies with Ability and/or Willingness to Crush Glass

Facility Name	Physical Address Address	City	St	Zip	TxDOT District	County	Glass	Delivery Method	Mobile Processing
Garrett Construction	Garrett Road	Ingleside	TX	78362	Corpus Christi	Nueces	Willingness	Truck	TRUE
Durwood Greene Construction Co.	500 Ward Street	Angleton	TX	77515	Houston	Brazoria	Ability / Willingness	Truck	TRUE
South Texas Aggregates	Main & Avenue B	Knippa	TX	78870	San Antonio	Uvalde	Ability / Willingness	Truck	TRUE
Amarillo Road Co. - Rock Crusher	Panhandle & West Texas	Amarillo	TX		Amarillo	Potter	Ability / Willingness	Truck	TRUE
Vulcan Materials Co.-1604 Quarry	4303 NE Loop 1604	San Antonio	TX	78247	San Antonio	Bexar	Ability	Truck	FALSE
American Materials Inc	2122 Highway 90A	Missouri City	TX	77459	Houston	Fort Bend	Ability / Willingness	Truck	TRUE
Redland Stone Products Co.	17910 IH-10 West	San Antonio	TX	78257	San Antonio	Bexar	Ability	Truck & Rail	TRUE
Williams Brothers-Bennington Crusher	6400 Hardy St	Houston	TX	77022	Houston	Harris	Ability	Truck	TRUE
Williams Brothers-Airtex Crusher	500 Airtex Road	Houston	TX	77073	Houston	Harris	Ability	Truck	TRUE
Texas Industries (TXI)	24403 FM 2978	Tomball	TX	77375	Houston	Harris	Ability / Willingness	Truck	TRUE
Pavers Supply Co. - Conroe Plant	9498 FM 1485	Conroe	TX	77303	Houston	Montgomery	Willingness	Truck	TRUE
Mathews Construction Company	641 E. Milam	Jasper	TX	75951	Beaumont	Jasper	Willingness	Truck	FALSE
Jobe Concrete Products Inc	#1 McKelligon Canyon Rd	El Paso	TX	79930	El Paso	El Paso	Ability / Willingness	Truck	TRUE
J.H. Strain & Sons Inc. #1 Crusher		Tye	TX	79563	Abilene	Taylor	Ability / Willingness	Truck	TRUE
Russell & Sons Construction Co.	307 S. Eastman Road	Longview	TX	75602	Tyler	Gregg	Ability	Truck & Rail	TRUE
Big City Crushed Concrete	11131 Goodnight Lane	Dallas	TX	75229	Dallas	Dallas	Ability	Truck	TRUE
Zack Burkett Co. - Perry Pit	SH 16 10 mi S of Graham	Graham	TX	76450	Wichita Falls	Young	Ability / Willingness	Truck	TRUE
H.V. Caver Inc	1303 W. Main	Atlanta	TX	75551	Atlanta	Cass	Willingness		FALSE
Zack Burkett Co. - Richards Pit	3 mi S of Jacksboro FM 4	Jacksboro	TX	76458	Fort Worth	Jack	Ability / Willingness	Truck	TRUE
Texarkana Asphalt Inc.	7700 Alumax Dr	Texarkana	TX	75501	Atlanta	Bowie	Willingness	Truck	FALSE
J.R. Thompson Inc.-Running N Quarry	3 mi of Saint Jo on SH 59	Saint Jo	TX	76265	Wichita Falls	Montague	Ability / Willingness	Truck	FALSE
L.A. Fuller & Sons Construction Inc.	9401 Amarillo Blvd. East	Amarillo	TX	79107	Amarillo	Potter	Ability / Willingness	Truck	TRUE
Vega Sand and Gravel Inc.	10mi N.of Vega on US 385	Vega	TX	79092	Amarillo	Oldham	Ability / Willingness	Truck	TRUE
Jones Brothers	1401 S. Grandview	Odessa	TX	79760	Odessa	Ector	Ability / Willingness	Truck	TRUE
M. Hanna Construction Company		Ennis	TX		Dallas	Ennis	Willingness	Truck	TRUE

The information provided in this table is based on submission by the companies listed. TxDOT does not represent that any of such information is necessarily accurate or correct. Likewise, TxDOT does not intend, nor should anyone conclude, that companies listed are endorsed in any way or for any purpose by TxDOT.

Any person or firm not listed, who believes that person or firm qualifies to be so listed, is invited to submit the required information. Please contact Andrew Andrasi at (512) 416-2562, for more information.

REFERENCES

Andrasi, Andrew. *Identifying Sources of Traditional and Alternative Road Building Materials for Texas Using GIS*, Master's Report, Southwest Texas State University, San Marcos, December 1998.

Cosento, P. J., Kalajian, E. H., Sheieh, C-S., and Heck, H. H. *Developing Specifications for Waste Glass and Waste-to-Energy Bottom Ash as Highway Fill Materials Volume 2 of 2 (Waste Glass)*, Report No. FL/DOT/RMC/06650-7754, June 1995.

Nash, P. T., Jayawickrama, P. W., Tock, R. W., Senadheera, S. P., Viswanathan, K., and Woolverton, B. *Use of Glass Cullet in Roadway Construction*, Research Report Number 0-1331-2, Texas Department of Transportation, August 1995.

Shin, C. J., and Sonntag, Victoria. *Using Recovered Glass as Construction Aggregate Feedstock*, Transportation Research Record No. 1437, Transportation Research Board, 1994.

Specifications

Draft TxDOT Specifications that allow for the use of glass cullet include:

- Embankments, Item 132
- Flexible Base, Item 247
- Asphalt Antistripping Agents, Item 301
- Excavation and Backfill for Structures, Item 400
- Retaining Wall, Item 423
- Pipe Underdrains, Item 556
- Open Graded Base Course

Specifications for the use of glass cullet in these construction applications should be finalized soon.

Item 132

DRAFT

EMBANKMENTS

132.2 Material.

Type E. This material shall consist of suitable recycled waste material such as crushed waste container glass cullet (referred to as glass cullet), which are free from vegetation and other objectionable matter and reasonably free from lumps of earth. The glass cullet shall also be free of hazardous products and the contractor is responsible for furnishing the engineer with documentation certifying that the glass cullet complies with Class 3 industrial waste requirements in accordance with 30 TAC 335.507. The source shall be approved by the engineer prior to use.

This material shall be suitable for forming a stable embankment and, when tested in accordance with Test Methods Tex-104-E, Tex-105-E, Tex-106-E, and Tex-107-E, Part II, and Tex-110-E shall meet the following requirements:

The liquid limit shall not exceed	45
The plasticity index shall not exceed	15
The bar linear shrinkage shall not be less than	2

The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

132.3 Construction Methods

(1) General.

Since all glass cullet material used in embankments shall not exceed 5/8 in., the material should be relatively safe to handle. However, precautions shall be taken for the safety of the construction personnel. When glass cullet is used in combination with other types of approved embankment materials, they shall be mixed thoroughly until a uniform mix is achieved to the satisfaction of the engineer.

Embankment material containing glass cullet shall not be used on the surface of the embankment unless it is indicated in plans or without the approval of the engineer.

Glass cullet may be used as an embankment material but only in combination with Type A, Type B, Type C or Type D embankment materials approved by the engineer. The maximum percentage of glass cullet in the embankment material mix shall not exceed 20 percent by weight of mix.

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet used as an embankment material shall not exceed 5 percent as estimated using the American Geological Institute Visual Method.

Item 247

DRAFT

FLEXIBLE BASE

247.2 Material.

(2) Physical Requirements.

(e) Type D. Type D flexible base material shall be recycled waste material such as crushed waste container glass (glass cullet) used in combination with Type A, Type B or Type C flexible base materials. Glass cullet shall be free from vegetation and other objectionable matter and reasonably free from lumps of earth. The glass cullet shall also be free of hazardous products and the contractor is responsible for furnishing the engineer with documentation certifying that the glass cullet complies with Class 3 industrial waste requirements in accordance with 30 TAC 335.507. The source shall be approved by the engineer prior to use. Glass cullet shall only be used as flexible base in pavements that will be surfaced prior to opening for traffic.

The percentage of glass cullet used in Type D flexible base material shall not exceed 20 percent by weight of the total mix.

The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet used as a flexible base material shall not exceed 5 percent as estimated using the American Geological Institute Visual Method.

(f) Type E. As shown on the plans.

247.3 Construction Methods

(1) General.

Precautions shall be taken for the safety of the construction personnel handling glass cullet. Glass cullet shall be mixed thoroughly with other approved sources of flexible base material until a uniform mix is achieved to the satisfaction of the engineer.

Item 301

DRAFT

ASPHALT ANTISTRIPPING AGENTS

301.2 Materials.

(2) **Liquid Antistripping Agent.**

When glass cullet is used as an aggregate in asphalt stabilized bases, lime and some liquid antistripping agents may not perform adequately. An antistripping agent such as a silane based compound may be used effectively in these instances.

Item 345

ASPHALT STABILIZED BASE (Plant Mix)

345.2 Material.

(1) Aggregate.

(a) Description. The aggregate shall be composed of one or more virgin (not previously used in construction) aggregates and/or reclaimed asphalt pavement (RAP). Samples of each aggregate shall be submitted for approval in accordance with Item 6, "Control of Materials".

Crushed waste container glass (glass cullet) may be used as a part of the virgin aggregate. The percent weight of glass cullet in the aggregate mix shall not exceed 5 percent of the total weight of the aggregate.

The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet used as a flexible base material shall not exceed 5 percent as estimated using the American Geological Institute Visual Method.

Asphalt antistripping agents shall be used wherever glass cullet is used in asphalt stabilized base. These antistripping agents shall be in accordance with Item 301, "Asphalt Antistripping Agents".

DRAFT

EXCAVATION AND BACKFILL FOR STRUCTURES

400.4 Shaping and Bedding.

Waste material such as crushed waste container glass (glass cullet) may be used as utility bedding. Glass cullet used for utility bedding shall be free from vegetation and other objectionable matter and reasonably free from lumps of earth. The glass cullet shall also be free of hazardous products and the contractor is responsible for furnishing the engineer with documentation certifying that the glass cullet complies with Class 3 industrial waste requirements in accordance with 30 TAC 335.507. The source shall be approved by the engineer prior to use.

Utility bedding material may comprise of up to 100 percent of glass cullet material. The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet when used as an utility bedding shall not exceed 5 percent as estimated using the American Geological Institute Visual Method.

Precautions shall be taken for the safety of the construction personnel handling glass cullet. When glass cullet is to be used in combination with other types of materials, they shall be mixed thoroughly until a uniform mix is achieved to the satisfaction of the engineer.

400.5 Backfill.

(1) General

Waste materials such as crushed waste container glass (glass cullet) may be used for many types of backfilling operations. Glass cullet used as backfill material shall be free from vegetation and other objectionable matter and reasonably free from lumps of earth. The glass cullet shall also be free of hazardous products and the contractor is responsible for furnishing the engineer with documentation certifying that the glass cullet complies with Class 3 industrial waste requirements in accordance with 30 TAC 335.507. The source shall be approved by the engineer prior to use.

The maximum allowable glass cullet content in backfill material shall be in accordance with the type of backfill. Backfill which will support any portion of the roadbed or embankment shall include a glass cullet content not more than 20 percent of the combined mix by weight. Backfill which does not support any portion of the roadbed or embankment may include a glass cullet content of up to 100 percent of the combined mix.

The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet used as an embankment material may depend on the type of backfill. The debris level of glass cullet used in backfill which will support any portion of the roadbed or embankment shall not exceed 5 percent as estimated using the American Geological Institute Visual Method. The debris level of glass cullet used in backfill which does not support any portion of the roadbed or embankment shall not exceed 10 percent as estimated using the American Geological Institute Visual Method.

Since all glass cullet material used in embankments shall not exceed 5/8 in., the material should be relatively safe to handle. However, general precautions shall be taken for the safety of the construction personnel. When glass cullet is used in combination with other materials, they shall be mixed thoroughly until a uniform mix is achieved to the satisfaction of the engineer.

Embankment material containing glass cullet shall not be used on the surface of the embankment unless it is indicated in plans or without the approval of the engineer.

(2) Bridge Foundations, Retaining Walls, And Culverts.

Glass cullet may be used as backfill in retaining walls and culverts in combination with other backfill materials which are approved for 100 percent use as backfill. The percent of glass cullet used in different applications and the allowable debris level in glass cullet shall be based on the criteria indicated in 400.5.1 above.

(3) Pipe.

Glass cullet may be used as backfill in pipeline applications in combination with other backfill materials which are approved for 100 percent use as backfill. The percent of glass cullet used in different applications and the allowable debris level in glass cullet shall be based on the criteria indicated in 400.5.1 above.

The maximum allowable glass cullet content in backfill material shall be in accordance with the type of backfill. Backfill which will support any portion of the roadbed or embankment shall include a glass cullet content not more than 20 percent of the combined mix by weight. Backfill which does not support any portion of the roadbed or embankment may include a glass cullet content of up to 100 percent of the combined mix.

The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet used as an embankment material may depend on the type of backfill. The debris level of glass cullet used in backfill which will support any portion of the roadbed or embankment shall not exceed 5 percent as estimated using the American Geological Institute Visual Method. The debris level of glass cullet used in backfill which does not support any portion of the roadbed or embankment shall not exceed 10 percent as estimated using the American Geological Institute Visual Method.

Since all glass cullet material used in embankments shall not exceed 5/8 in., the material should be relatively safe to handle. However, general precautions shall be taken for the safety of the construction personnel. When glass cullet is used in combination with other materials, they shall be mixed thoroughly until a uniform mix is achieved to the satisfaction of the engineer.

Embankment material containing glass cullet shall not be used on the surface of the embankment unless it is indicated in plans or without the approval of the engineer.

(2) Bridge Foundations, Retaining Walls, And Culverts.

Glass cullet may be used as backfill in retaining walls and culverts in combination with other backfill materials which are approved for 100 percent use as backfill. The percent of glass cullet used in different applications and the allowable debris level in glass cullet shall be based on the criteria indicated in 400.5.1 above.

(3) Pipe.

Glass cullet may be used as backfill in pipeline applications in combination with other backfill materials which are approved for 100 percent use as backfill. The percent of glass cullet used in different applications and the allowable debris level in glass cullet shall be based on the criteria indicated in 400.5.1 above.

Item 423

DRAFT

RETAINING WALL

423.2 Material.

Backfill Material

(1) Backfill for spread footing retaining walls shall be in accordance with Item 132, "Embankment", Types B or D, unless otherwise shown on the plans.

(2) Backfill for MSE walls may include crushed waste container glass (glass cullet) except when cement stabilized backfill material is used. The backfill material shall be free from organic or otherwise deleterious materials, and shall conform to the following gradation limits as determined by Test Method Tex-110-E.

The use of glass cullet as a structural backfill shall be limited to a maximum of 20 percent of the total backfill material, by weight. In non-structural backfill applications, up to 100 percent of glass cullet may be used.

The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet used as backfill may depend on the type of retaining wall backfill. The debris level of glass cullet used in structural retaining wall backfill shall not exceed 5 percent as estimated using the American Geological Institute Visual Method. The debris level of glass cullet used in non-structural retaining wall backfill shall not exceed 10 percent as estimated using the American Geological Institute Visual Method.

Since all glass cullet material used in embankments shall not exceed 5/8 in., the material should be relatively safe to handle. However, general precautions shall be taken for the safety of the construction personnel. When glass cullet is used in combination with other materials, they shall be mixed thoroughly until a uniform mix is achieved to the satisfaction of the engineer.

Embankment material containing glass cullet shall not be used on the surface of the embankment unless it is indicated in plans or without the approval of the engineer.

Item 556

DRAFT

PIPE UNDERDRAINS

556.2 Material.

(2) Filter Material. Filter material for use in backfilling trenches under, around and over underdrains shall consist of hard, durable, clean sand, gravel, crushed stone, crushed shell, crushed waste container glass (glass cullet) or other materials specified on the plans and shall be free from organic matter, clay balls or other deleterious matter. Unless otherwise shown in the plans, crushed limestone will not be permitted.

Up to 100 percent of glass cullet may be used as a filter material in pipe underdrains. The glass cullet material shall conform to the following gradings unless shown otherwise in plans.

Sieve Size	Cumulative Percent Retained on Sieve
5/8 in.	0
3/8 in.	0-10
No. 4	30-50
No. 10	50-75
No. 40	80-90
No. 200	90-100

A certain amount of debris is allowed in the glass cullet. Such debris may include pieces of paper labels, plastic caps, metal caps and cork. The level of debris allowed in glass cullet used as a filter material in pipe underdrains shall not exceed 5 percent as estimated using the American Geological Institute Visual Method.

556.3 Construction Methods

Precautions shall be taken for the safety of the construction personnel handling glass cullet. When glass cullet is to be used in combination with other types of materials, they shall be mixed thoroughly until a uniform mix is achieved to the satisfaction of the engineer.

Other Recommended Uses

DRAFT

OPEN GRADED BASE COURSE

Material

Crushed waste container glass may be used as aggregate in open graded drainable base courses. The use of glass cullet in this application shall be governed by Item 345, "Asphalt Stabilized Base". It is recommended that glass cullet shall be used in combination with other approved granular base material. The percent glass cullet in such mixes shall not exceed 5 percent of the total aggregate by weight.

The master gradation to be used in the open graded base course shall be as follows:

Sieve Size	Cumulative Percent Passing
1.5 in.	100
1.0 in.	95-100
1/2 in.	25-60
No. 4	0-10
No. 8	0-5