Fill Materials at Integral End Bents

Report Number: KTC-22-03/SPR19-572-1F

DOI: https://doi.org/10.13023/ktc.rr.2022.03

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College of Engineering, University of Kentucky, Lexington, Kentucky

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Research Report

KTC-22-03/SPR19-572-1F

Fill Materials at Integral End Bents

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Kentucky Transportation Cabinet
Commonwealth of Kentucky

March 2022

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No
KTC-22-03/SPR19-572-1F		

4. Title and Subtitle Fill Materials at Integral End Bents	**5. Report Date** March 2022 **6. Performing Organization Code** KTC-22-03/SPR19-572-1F
7. Author(s): Charlie Sun, Tony Beckham	**8. Performing Organization Report No.**
9. Performing Organization Name and Address Kentucky Transportation Center College of Engineering University of Kentucky Lexington, KY 40506-0281	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** SPR 19-572
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building Frankfort, KY 40622	**13. Type of Report and Period Covered** **14. Sponsoring Agency Code**

15. Supplementary Notes
Prepared in cooperation with the Kentucky Transportation Cabinet

16. Abstract
Jointless bridge designs have become increasingly popular due to their low construction and maintenance costs. But this design carries risks. Most notably, integral end bents can be displaced and undergo settlement due to soil movement in embankments and loads carried by the superstructure. In response, the Kentucky Transportation Cabinet (KYTC) devised a novel treatment for end bent and abutment backfills on low- and middle-span concrete bridges in which elasticized geofoam is placed between geosynthetically confined soil and an integral end bent (GCS-IEB). However, this design requires modification where the elasticized geofoam and overlying pavement meet. Using elasticized geofoam is also costly. In response, this study identifies less expensive substitutes for elasticized geofoam that would not be damaged by bridge movements and which would reduce the settlement of integral end bents. Two promising materials were evaluated whose properties are similar to elasticized geofoam but which cost significantly less — shredded tire chips and recycled tire granules. Using a new lab procedure, researchers evaluated the recoverable deformation and maximum resistant stress of different samples, ultimately identifying a recycled tire derivative that is the best low-cost alternative to elasticized geofoam. Step-by-step installation methods are provided to guide the onsite installation of alternative materials. One method applies to recycled tire derivatives delivered in bags, while the other applies to materials that delivered in bulk and placed into baskets onsite.

17. Key Words	18. Distribution Statement
geosynthetically confined soil, GCS, integral end bent, recycled tire derivative, chip, particle	Unlimited with approval of the Kentucky Transportation Cabinet

19. Security Classification (report)	20. Security Classification (this page)	21. No. of Pages	19. Security Classification (report)
Unclassified	Unclassified	28	

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Acknowledgements

The authors would like to express their thanks to Professor Fuqian Yang and Yulin Zhang, Ph.D. student, Department of Chemical and Materials Engineering, College of Engineering, University of Kentucky, who helped with testing cyclic properties on different materials.

The authors would like to thank Dr. Chris VanDyke for constructive criticism of the manuscript.

The authors also want to thank and acknowledge the members of the Study Advisory Committee. Their guidance and advice during the course of this study was most helpful. In particular, the authors would like to thank Mr. Bart Asher and Mr. Michael Carpenter (former and current Directors of Division of Structural Design, respectively, Kentucky Transportation Cabinet) Chairmen of the Study Advisory Committee, for their leadership.

Executive Summary

Jointless bridge designs have become increasingly popular at state transportation agencies because they cost less to construct and maintain than other bridge types. However, adopting this design can result in the displacement and settlement of integral end bents due to soil movement in embankments and loads carried by the superstructure. To address this challenge, Kentucky Transportation Cabinet (KYTC) Division of Structural Design staff have devised a novel treatment for end bent and abutment backfills on low- and middle-span concrete bridges in which elasticized geofoam is placed between geosynthetically confined soil and an integral end bent (GCS-IEB). District construction staff have commented that the design needs to be modified where the elasticized geofoam and overlying pavement meet, and that elasticized geofoam is quite expensive. This study explores less expensive substitutes for elasticized geofoam that would not be damaged by bridge movements and reduce the settlement of integral end bents.

Kentucky Transportation Center (KTC) researchers developed a new test method to identify alternative materials which possess quasi-stable elastic properties similar to elasticized geofoam. Benchmarks from elasticized geofoam testing were used to evaluate the performance of alternative materials. Two promising materials were identified whose properties are similar to elasticized geofoam but which cost significantly less — shredded tire chips and recycled tire granules. Researchers tested a total of seven (7) materials derived from recycled tires. Readers can view the full test results in Table 3.3. Key findings are presented below.

- Shredded Tire Chip 1 performed the best in terms of recoverable deformation. Its recoverable deformation was 4.98% at a predefined strain of 15%. Under the same strain elasticized geofoam had a recoverable deformation of 4.48%. Conversely, the resistant stress of Shredded Tire Chip 1 was 4.55 psi at a predefined strain of 15%, significantly less (41.67%) than the 7.80 psi of elasticized geofoam at same strain. This may limit its use where large resistant stress is needed.

- Accounting for recoverable deformation and maximum resistant stress, Granule Recycled Tire Particle 09 – 18 exhibited the best performance at a predefined strain of 15%. Its maximum resistant stress reached 8.37 psi — 7.3% greater than the 7.80 psi of elasticized geofoam. Its recoverable deformation was 3.72%, or 17% less than the 4.48% measured for elasticized geofoam. This recycled tire derivative may be the best low-cost alternative to elasticized geofoam.

Because the installation of chips/particles on construction sites is the biggest challenge in using alternative materials, the report proposes two installation methods:

- Method 1 is used for bagged recycled tire derivatives. These derivatives are stacked against the back of the end bent/abutment and placed inside of geotextile reinforcement. Granular backfill material is then spread. The lift is compacted with a suitable compactor until there is no visible sign of further compression or settlement. Each lift (i.e., layer) consisting of bagged and wrapped tire derivatives and backfill must not exceed one (1) foot.

- Method 2 is used for bulk-packed recycled tire derivatives. Chips/particles are placed in foldout baskets located against the back of the end bent/abutment. Granular backfill material is then spread and enclosed with geotextile reinforcement. The lift is compacted with a suitable compactor until there is no visible sign of further compression (settlement). Each lift (i.e., layer) consisting of wrapped baskets and granular backfill material must not exceed (1) foot.

In both methods the thickness of the inclusion shall be a minimum 10 times the Design Compression.

Due to limited construction activities, no site has been identified for demonstration/verification purpose using tire derivatives. When KYTC selects a site, it will be developed, instrumented, and monitored.

Section 1 Introduction

1.1 Background

Previous research has shown that generic geosynthetically confined soil (GCS) structures can have bearing capacities and safety factors more than 10 times those of mechanically stabilized earth (MSE) walls.[1] Wu et al. demonstrated that GCS walls and abutments can withstand significant earthquakes (> 7.0 magnitude on the Richter scale).[2] GCS structures behave as GeoMonoliths or unique composites. Unique Composite behavior exceeds the sum of its components.[3] State-of-the art GCS technology is used to fabricate bridge end bents in a better, safer, quicker, easier, and cheaper manner. Data from previous research[4] has revealed that elasticized geofoam can offset the displacement of bridge superstructures caused by temperature fluctuations.

Kentucky Transportation Cabinet (KYTC) district construction staff and contractors have expressed concern about the cost of (EEPS) polystyrene foam (i.e., elasticized geofoam). This report discusses alternative, lower-cost materials whose properties and functions are similar to elasticized geofoam. We present in-situ data on the displacement and settlement of integral end bents caused by soil moving in embankments and loads from the superstructure that are the product of jointless design. Our analysis will help readers better understand interactions between soil and integral end bents. KYTC can use project findings to increase the use of integral end bents on bridge projects; preserve resources by eliminating expansion joints, reducing construction costs, and reducing future maintenance costs; and strengthen structures to accommodate seismic forces.

1.2 Problem Statement

At select sites KYTC has adopted a modified procedure for designing and constructing approach fills at bridges with integral end bents. The modified approach involves placing elasticized geofoam between the geosynthetic reinforced soil (GRS) backfill and bridge end. Data from two sites have shown this reduces settlement at bridge approaches. KYTC district construction staff have argued for modifying the design of approach fills where the elasticized geofoam and overlying pavement meet. This study explores alternative materials — along with their dimensions and placement — that lower the cost and complexity of construction, prevent damage by bridge movement, and potentially reduce settlement.

Section 2 Objectives

This study has two objectives:

- Identify materials which have moderate compressible properties and strong bearing capacity similar to elasticized geofoam but which are less expensive. Identify the best alternative fill material to replace elasticized geofoam in integral end bent test sections construction (Figure 2.1).

- Develop specifications and methods for incorporating the new fill material into integral end bent construction.

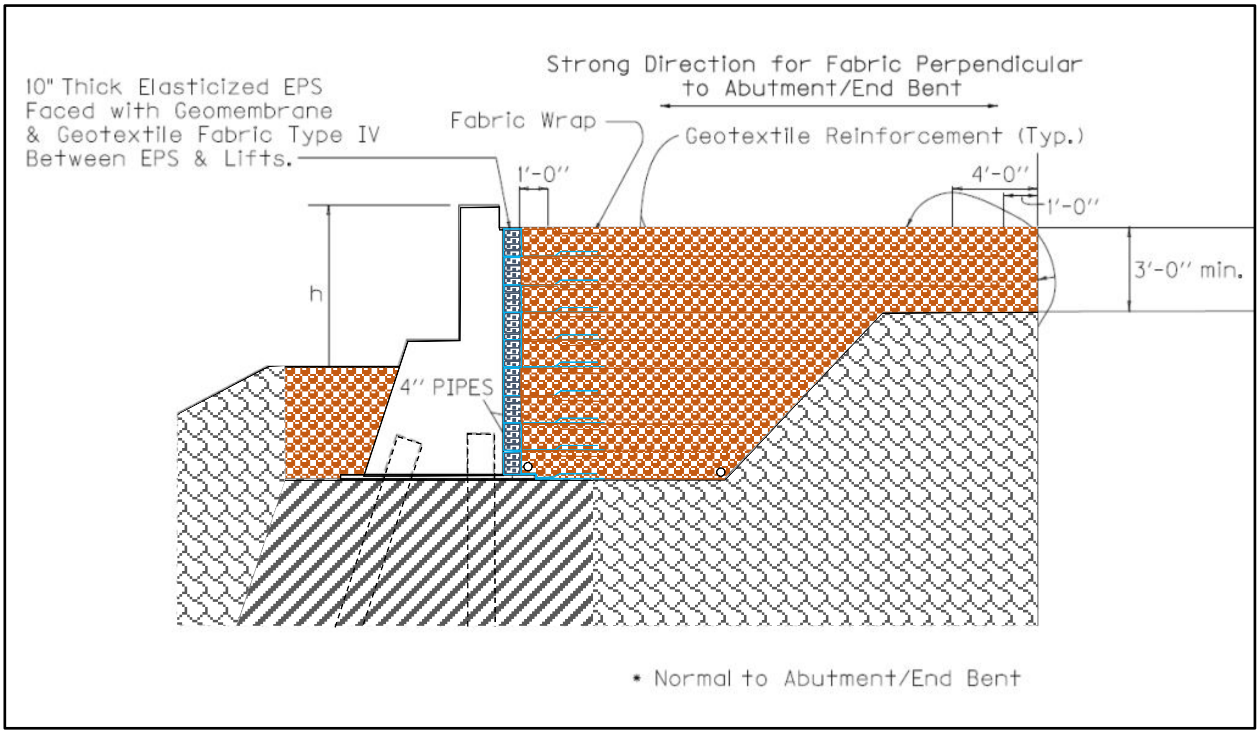

Figure 2.1 Geosynthetically Confined Soil and Integral End Bent (GCS-IEB)

Section 3 Identifying Alternative Materials Through Laboratory Testing

We identified two promising materials whose properties are similar to elasticized geofoam but which cost significantly less — shredded tire chips and recycled tire granules.

3.1 Pioneer Test to Find Correct Procedures

No standard test is available for identifying the loading-unloading properties of elasticized geofoam in end bent use. When evaluating alternative materials, the most important property to assess is their loading-unloading behaviors. Viable alternatives must exhibit performance similar to elasticized geofoam. To evaluate loading-unloading behavior, we first conducted a pioneer test on a sample of recycled tire granules ranging in size from 0.157” to 0.375”. The pioneer test measured the cyclic rate and number of cycles needed to reach a quasi-stable elastic recovery deformation under predefined strains of 5%, 10%, and 15%.

3.1.1 Apparatus

We conducted pioneer testing using a SHIMADZU AGS-X Tabletop Precision Universal Tester (Figure 3.1; Table 3.1 lists its specifications).

Table 3.1 SHIMADZU AGS-X Tabletop Precision Universal Tester Specifications

Max. Load Capacity		5 kN
Force Measurement		Tensile, compression, or tensile and compression
Crosshead Speed Range		0.001 to 1000 mm/min (stepless)
Effective Test Width		425 mm
Crosshead Position Detection	***Display Method***	Digital display (display resolution: 0.001 mm)
	Positional Accuracy	±0.1% indicated value or ±0.01 mm, whichever is larger
Data Capture Rate		1000 Hz max.

Figure 3.1 SHIMADZU AGS-X Tabletop Precision Universal Tester

3.1.2 Test Sample Preparation

(1) Fill a cylindrical steel container (diameter = 6 in.; height = 12 in.) with recycled tire granules (Figure 3.2).
(2) Compact the granules by hand — shake the container 12 times and tap the surface with a mallet 48 times. Follow this procedure regardless of the proportion of the container filled with granules. We tested three levels — 2/5, 3/4, and full with additional ring (Figure 3.3a, 3.3b, 3.3c),
(3) Once the container is filled, level the surface with a steel ruler (Figure 3.3d).
(4) Record the container’s weight.

Figure 3.2 Cylindrical Steel Container

Figure 3.3 Method of Filling Cylindrical Steel Containers with Recycled Tire Granules

3.1.3 Test Procedure

Cyclic compression tests were performed on samples of each material at predefined strains of 5%, 10%, and 15%, which correspond to predefined height changes of 0.6, 1.2 and 1.8 in., respectively. After each loading, the loading head reverts to the initial reference position (unloading) and is ready for the next loading. For all levels of strain, the time for each loading-unloading cycle is one (1) minute. During each compression cycle, the deformation of each sample reaches the predefined strain, and the loading head reverts to the initial (undeformed) position to release the load applied to the sample. All stress-strain data were recorded at a 100 Hz rate (Figure 3.4).

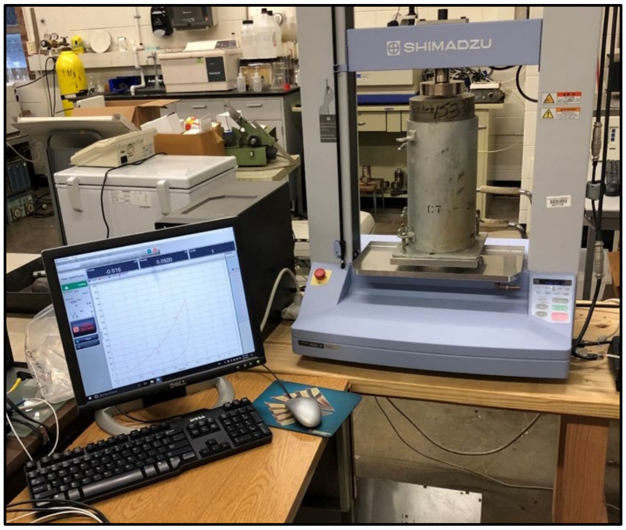

Figure 3.4 Sample Testing

3.1.4 Pioneer Testing Results, Findings, and Discussion

Figures 3.5 and 3.6 summarize our results. Figure 3.5 shows data from Cycles 1 – 20 for the three (3) tests. For clarity, Figure 3.6 only presents data for Cycles 16 – 20 of the three (3) tests.

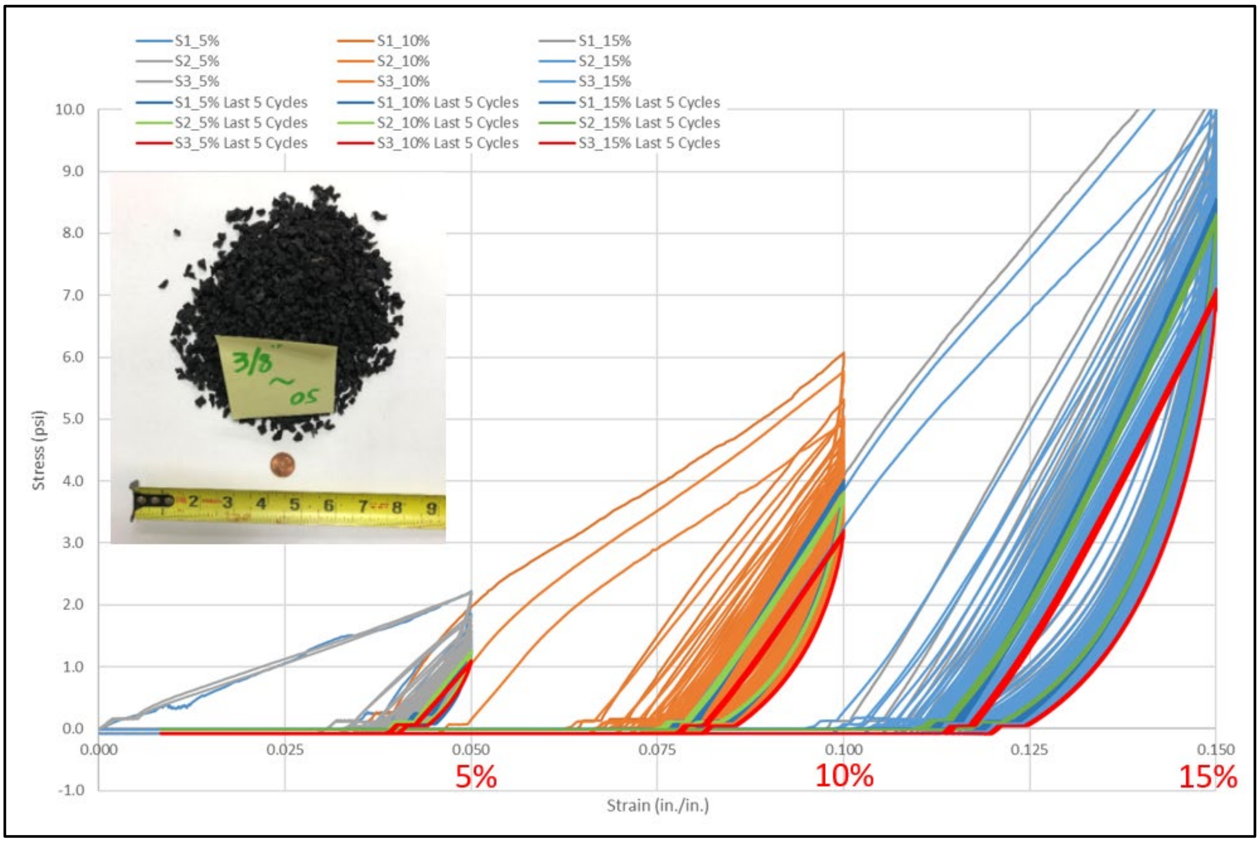

Figure 3.5 Stress-Strain Curves (Cycles 1 – 20)

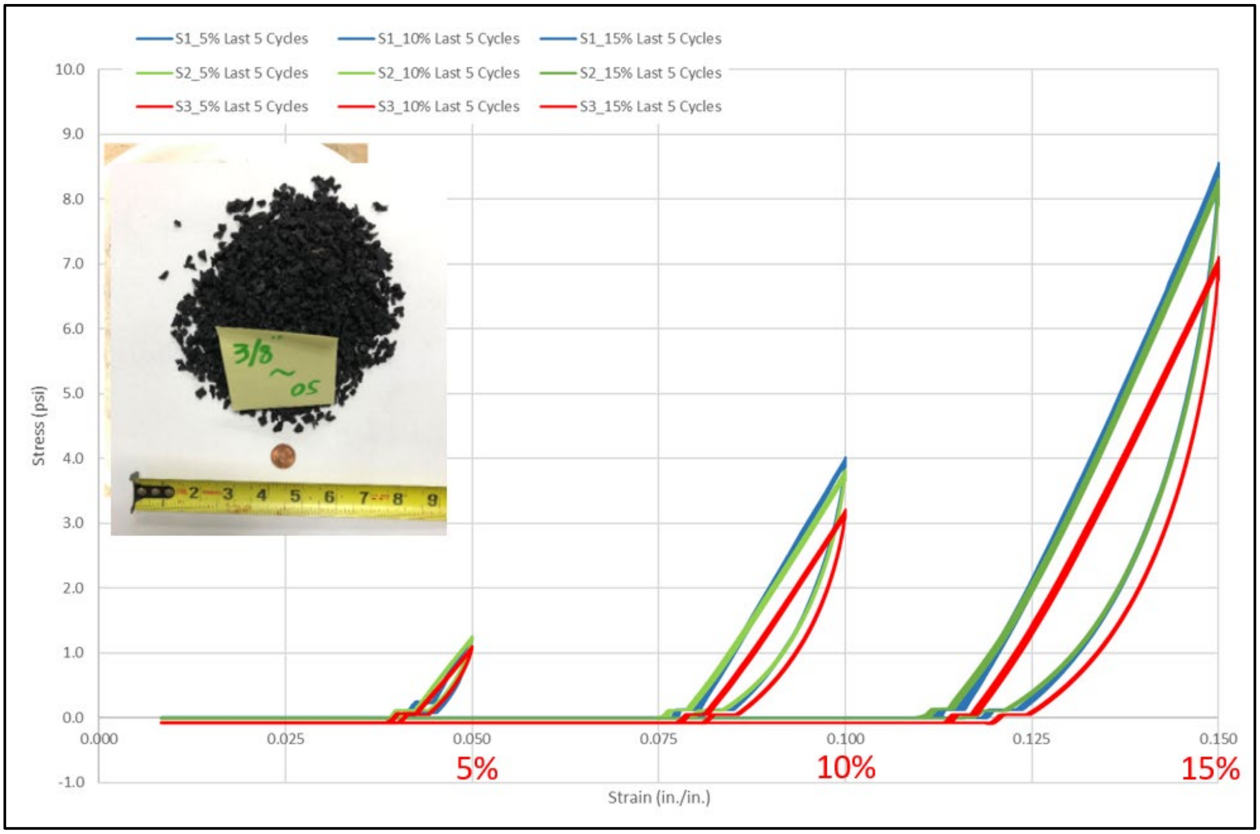

Figure 3.6 Stress-Strain Curves (Cycles 16 – 20)

The most critical finding is that the stable cycle begins at Cycle 16. This indicates that 20 test cycles is sufficient to reach a quasi-stable elastic recovery under predefined strain levels of 5%, 10%, and 15%. A loading-unloading rate of 1 cycle/minute is practical and suitable for our purpose.

For a given deformation, stresses peak at Cycle 1 and diminish to their lowest point during Cycles 16 – 20. This behavior results from the thorough consolidation of particles after certain loading-unloading cycles. Test results also reveal that two kinds of deformations — recoverable and unrecoverable deformations — are present in all loading-unloading cycles. The recoverable deformation is proportional to total measured sample deformation.

3.2 Laboratory Tests of Alternative Materials

Applying test procedures outlined in Section 3.1, we identified which material's performance most closely matches that of elasticized geofoam.

3.2.1 Benchmark Test on Elasticized Geofoam

To establish performance benchmarks for elasticized geofoam, we tested three (3) samples of the material. Each sample had a diameter of 6 in. and height of 12 in. (Figure 3.7). At a predefined strain of 5%, the elasticized geofoam's compressive strength was 7 psi. This increased to 8.5 psi at 10% strain. Flexural strength was 13 psi.

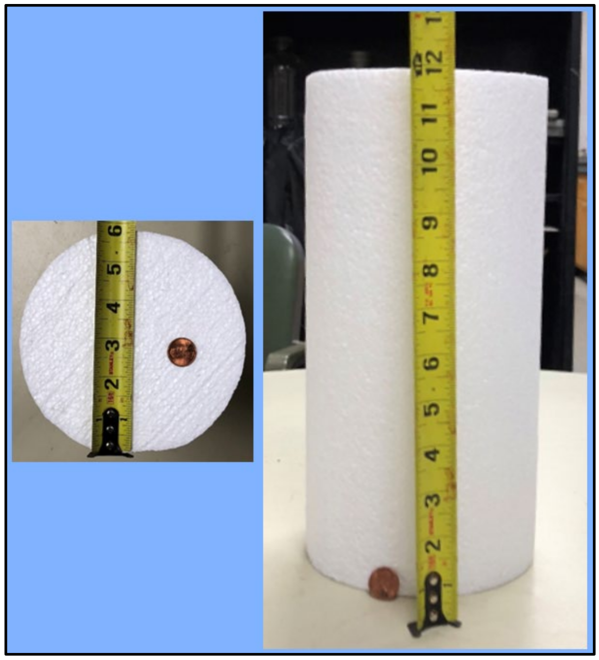

Figure 3.7 Elasticized Geofoam Sample

Figure 3.8 presents the results of benchmark testing. For clarity, the figure only displays data for Cycles 16 – 20.

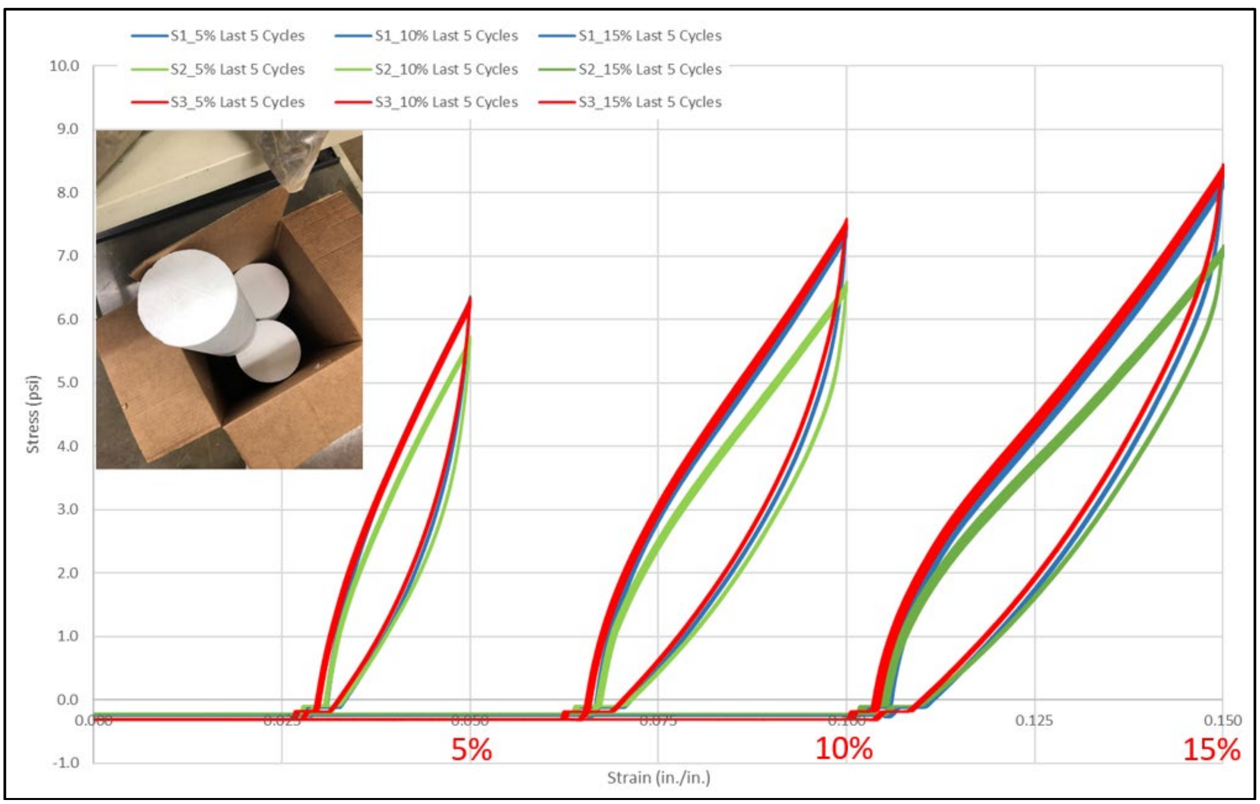

Figure 3.8 Stress-Strain Curves for Elasticized Geofoam Samples (Cycles 16 – 20)

3.2.2 Tests on Selected Materials – Recycled Tire Derivatives

We tested six (6) recycled tire derivatives to compare their quasi-stable elastic properties to those of elasticized geofoam. For testing, we used three (3) samples of each derivative. Two of the derivative materials consisted of recycled shredded tire chips (Figures 3.9a and 3.9b). The other four (4) consisted of recycled tire granules of varying sizes (Figures 3.9c – 3.9f).

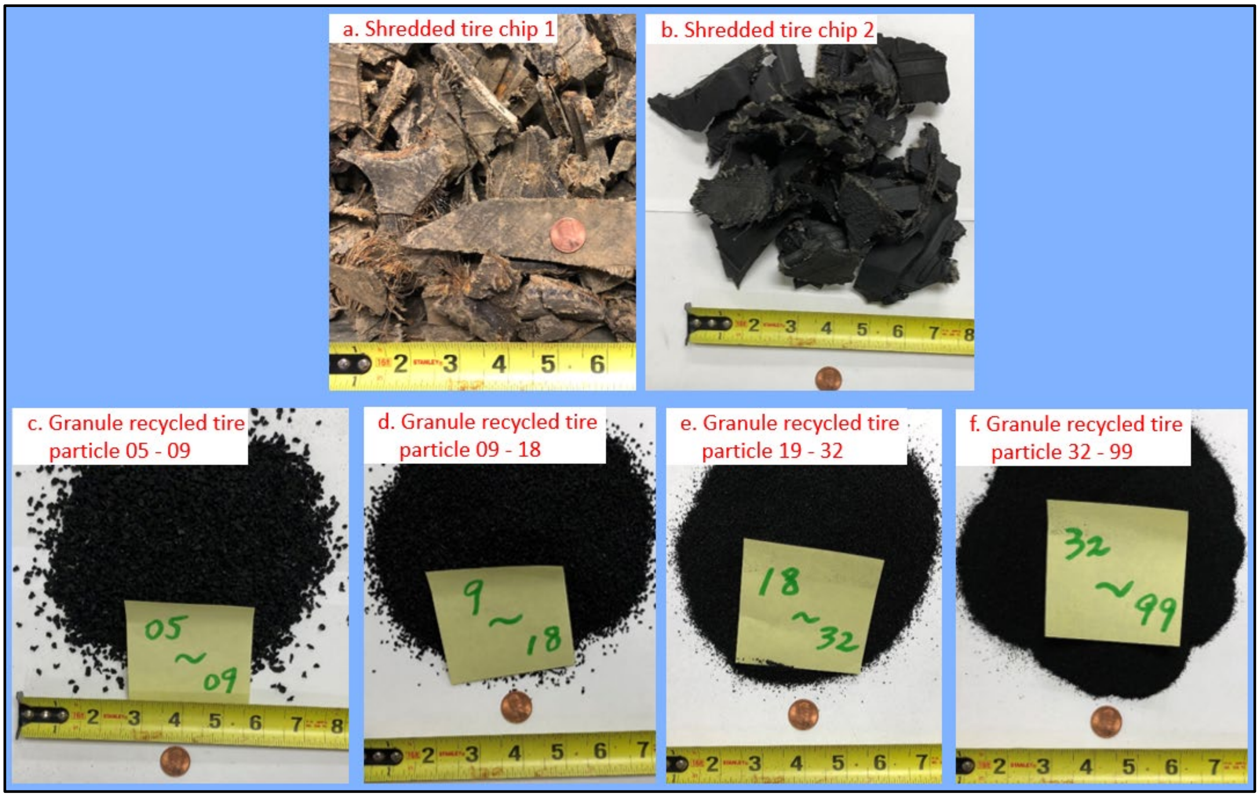

Figure 3.9 Recycled Tire Derivatives

Shredded Tire Chip 1 came from a previous project and had been stored in the laboratory for years. Shredded Tire Chip 2 was sourced from the same company that supplied the recycled tire granules. Table 3.2 lists the size ranges of each material.

Table 3.2 Size Ranges of Recycled Tire Derivatives

Sample Name	Size Range (in)
Recycled Shredded Tire Chip 1	2.5 – 5.5
Recycled Shredded Tire Chip 2	1.5 – 3.5
Pioneer Test Sample 3/8" – 05	0.157 – 0.375
Granule Recycled Tire Particle 05 – 09	0.0862 – 0.157
Granule Recycled Tire Particle 09 – 18	0.0394 – 0.0862
Granule Recycled Tire Particle 18 – 32	0.0218 – 0.0394
Granule Recycled Tire Particle 32 – 99	0.0059 – 0.0218

3.2.3 Test Results, Comparison, and Discussions

Table 3.2 summarizes results of the elasticized geofoam benchmark test, pioneer test, and recycled tire derivative tests. The listed values represent the average performance of the three (3) samples used in testing.

Table 3.3 Results for the Elasticized Geofoam Benchmark Test, Pioneer Test, and Selected Recycled Tire Derivative Tests

Sample Name	Predefined 5% Strain		Predefined 10% Strain		Predefined 15% Strain	
	Recoverable Strain	Max. Stress (psi)	Recoverable Strain	Max. Stress (psi)	Recoverable Strain	Max. Stress (psi)
Elasticized geofoam (Benchmark)	**1.90%**	**6.04**	**3.41%**	**7.09**	**4.48%**	**7.80**
Pioneer Test Sample 3/8” – 05	0.75%	1.16	1.92%	3.60	3.35%	7.85
Recycled Shredded Tire Chip 1	**1.91%**	**1.15**	**3.09%**	**2.46**	**4.98%**	**4.55**
Recycled Shredded Tire Chip 2	1.09%	0.6	2.32%	1.81	4.07%	3.56
Granule Recycled Tire Particle 05 – 09	0.59%	1.17	1.93%	3.81	3.38%	8.20
Granule Recycled Tire Particle 09 – 18	**0.78%**	**1.33**	**2.13%**	**4.11**	**3.72%**	**8.37**
Granule Recycled Tire Particle 18 – 32	0.72%	1.09	1.84%	3.21	3.28%	6.34
Granule Recycled Tire Particle 32 – 99	0.47%	0.88	1.58%	2.50	2.93%	4.91

For all samples, the recoverable strain and predefined strain were positively correlated. Maximum resistant stress was positively correlated with predefined strain as well. The maximum recoverable strain and maximum resistant stress were observed for neither the largest nor smallest recycled tire granules. For the largest particles, larger voids may limit the recoverable strain and resistant stress, while the smallest particles may deactivate the elastic features in granules, which are made of rubber. Recoverable strains for Shredded Tire Chip 1 — at all strain levels — exceeded those measured in all other materials. Shredded Tire Chip 1 differs from Shredded Tire Chip 2 in that it contains more rubber ingredients.

Among recycled tire derivatives, Granule Recycled Tire Particle 09 – 18 had the best resistant stress fit (Figure 3.10). Shredded Tire Chip 1 exhibited the best recoverable deformation fit (Figure 3.11). At a predefined strain of 15%, the recoverable strains of elasticized geofoam and Shredded Tire Chip 1 were 4.48% and 4.98%, respectively. At the same level of strain, the maximum resistant stresses were 7.80 psi for elasticized geofoam and 8.37 psi for Granule Recycled Tire Particle 09 – 18. Thus, Granule Recycled Tire Particle 09 – 18 is the most promising low-cost alternative to elasticized geofoam.

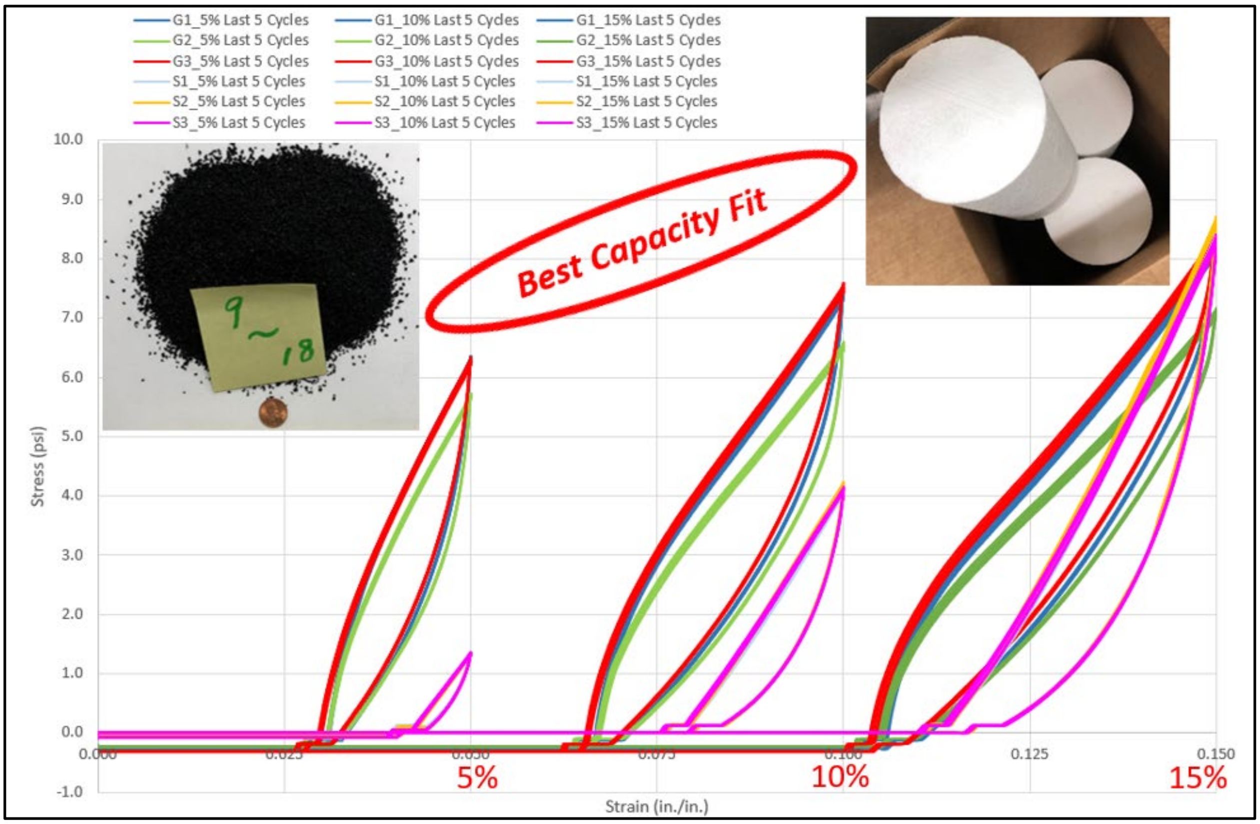

Figure 3.10 Performance of Granule Recycled Tire Particle 09 – 18

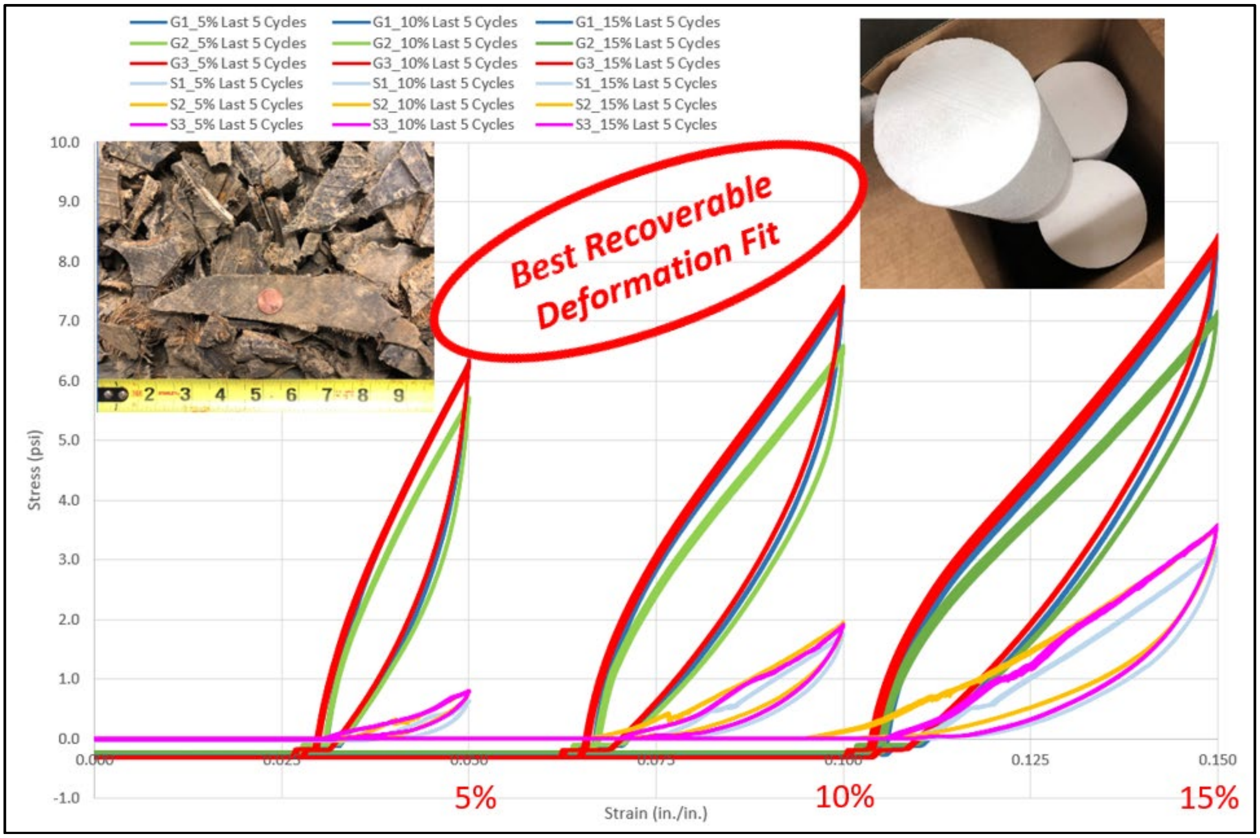

Figure 3.11 Performance of Shredded Tire Chip 1

Section 4 Proposed Installation Methods for Elasticized Geofoam Substitutes

When using shredded tire chips or recycled tire granules, onsite installation is the biggest challenge. Elasticized geofoam comes in large pieces that are easily installed, whereas chips and particles are discrete materials. They are packed in either bags (Figure 4.1a) or bulk (Figure 4.1b) for delivery. Two methods for onsite installation are proposed below.

Figure 4.1 Delivery Methods for Packing Recycled Tire Derivatives

4.1 Method 1 — Stacking Bagged Recycled Tire Derivatives

1. Place geotextile reinforcement where the granular backfill material will meet embankment material in accordance with Section 214 of the Standard Specifications.
2. Stack bags of recycled tire derivatives against the back of the end bent/abutment to a height of one foot.
3. Enclose bags in geotextile reinforcement. When placing the geotextile reinforcement make sure (a) the strongest direction is perpendicular to the end bent/abutment and (b) the material is taut and wrinkle free.
4. Starting at the edges of the enclosed bags and working outward and perpendicular to the end bent/abutment spread backfill material. Working in this direction prevents the geotextile reinforcement from wrinkling or developing slack.
5. Using a suitable compactor, compact the bagged recycled tire derivatives and backfill material until there are no visible signs of further compression. Apply a minimum of four passes. Hand-operated compaction equipment (e.g., lightweight mechanical tampers, vibratory plates, rollers) must be used within three (3) feet of the back of the end bent/abutment.
6. Repeat this process of creating one-foot lifts until the desired height is reached.

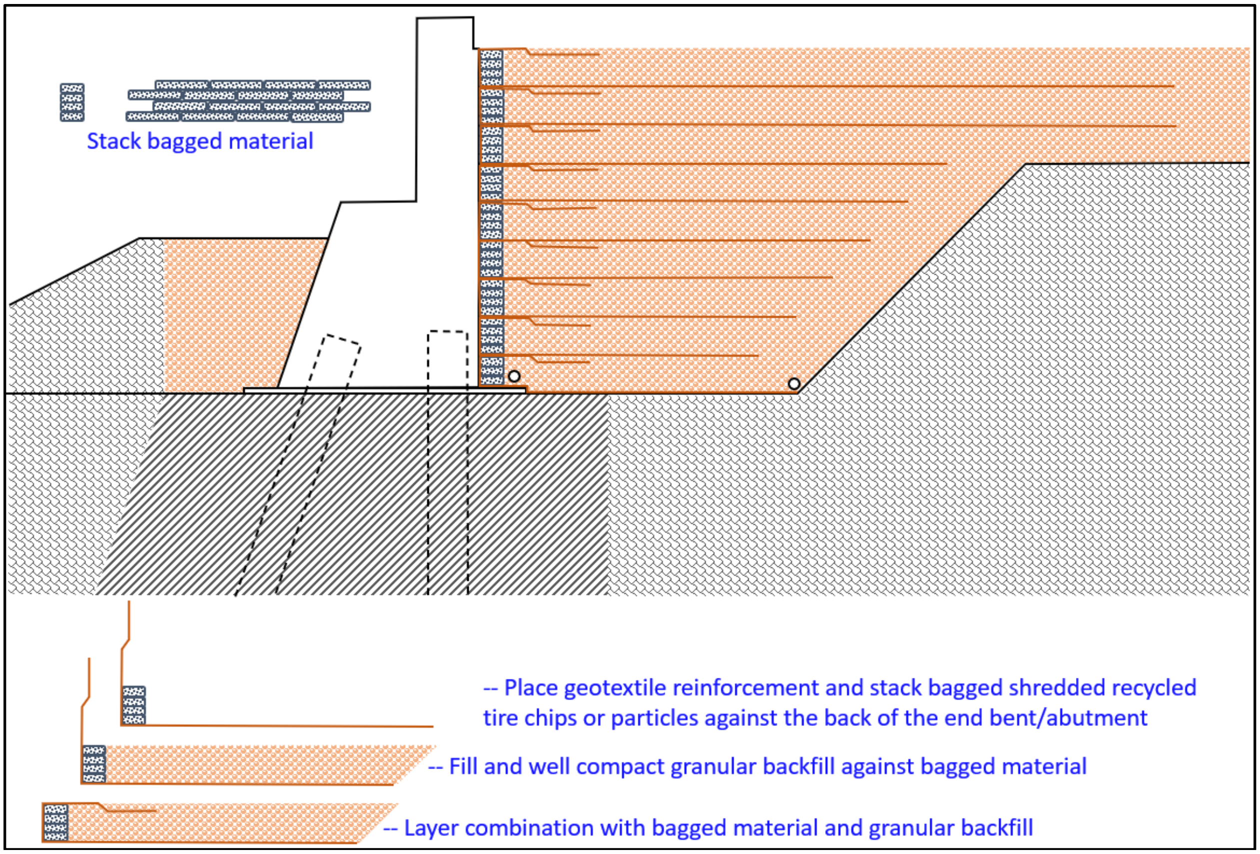

Figure 4.2 Method 1 — Installing and Securing Bagged Materials

4.2 Method 2 — Placement of Recycled Tire Derivatives in Foldout Baskets

1. Place foldout baskets against the back of the end bent/abutment.
2. Fill the baskets with recycled tire derivatives. Place geotextile reinforcement where the granular backfill material will meet embankment material in accordance with Section 214 of the Standard Specifications. When placing the geotextile reinforcement make sure (a) the strongest direction is perpendicular to the end bent/abutment and (b) the material is taut and wrinkle free. Lifts should not exceed one (1) foot.
   - Note that filled baskets *are not* enclosed in geotextile reinforcement. Unlike Method 1, which encloses bags in geotextile reinforcement.
3. Starting at the edges of the baskets and working outward and perpendicular to the end bent/ abutment, spread backfill material. Working in this direction prevents the geotextile reinforcement from wrinkling or developing slack.
4. Using a suitable compactor, compact the basketed recycled tire derivatives and backfill material until there is no visible sign of further settlement. Apply a minimum of four passes. Hand-operated compaction equipment (e.g., lightweight mechanical tampers, vibratory plates, rollers) must be used within three (3) feet of the back of the end bent/abutment.
5. Repeat this process of creating one-foot lifts until the desired height is reached.

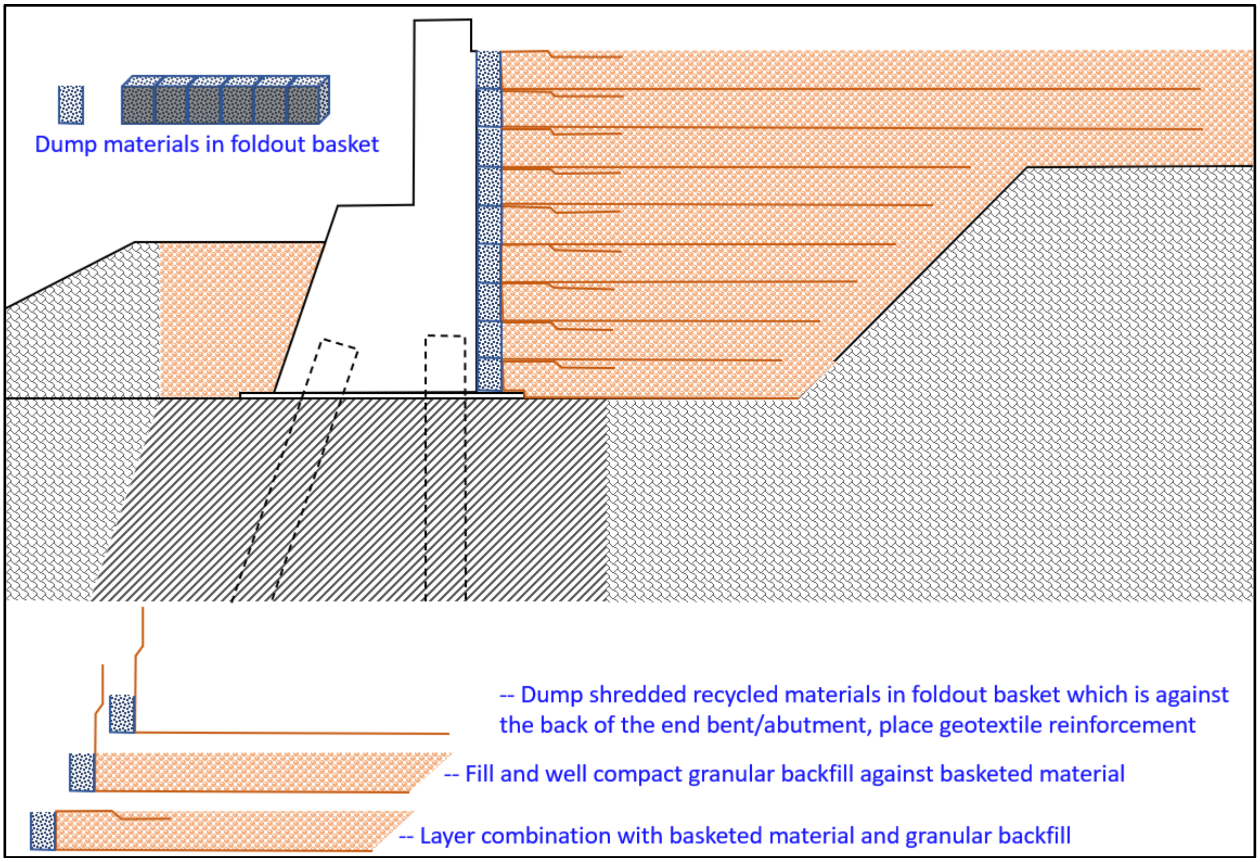

Figure 4.3 Method 2 — Installing and Securing Basketed Materials

Both methods can reduce labor costs for installing recycled tire derivatives. Method 1 stacks bagged materials as needed, while Method 2 is easily accomplished using foldout baskets that are filled with dumped bulked materials. Both methods are workable and practical.

Section 5 Specifications and Key Issues

KYTC has a well-documented special note and special provisions that provide instructions on using geotextile reinforcements and elastic inclusions for end bent and abutment backfills. Appendices A – D include these special notes.

- Appendix A, *Special Note for Treatment of End Bent or Abutment Backfills Using Geotextile Reinforcement and Elastic Inclusion*
- Appendix B, *Special Provision No. 69 Embankment at Bridge End Bent Structures*
- Appendix C, *Standard Drawing No. Rgx-100-06 Treatment of Embankments at End-Bents*
- Appendix D, *Standard Drawing No. Rgx-105-08 Treatment of Embankments – Details*)

We have modified the special note in Appendix A to address the use of elasticized geofoam and recycled tire derivatives.

It is imperative to adhere to the following guidelines when using recycled tire derivatives in lieu of elasticized geofoam:

- When granular or rock embankment is required for embankment construction, place material in loose lifts that do not exceed a height of 2 ft. Compact material a vibrating smooth wheel roller capable of producing a minimum centrifugal force of 15 tons.
- For GCS installation, geotextile reinforcement and granular backfill are placed in lifts that are not to exceed 1 ft. (pursuant to Standard Drawing No. Rgx-105-08 (Appendix D)).
- For GCS installation, geotextile reinforcement must wrap around and enclose the backfill material on three sides (the end bent/abutment and side slopes).
- For GCS installation, a suitable compactor must be used to compact each lift of the backfill material until there is no visible sign of further compression.
- For GCS installation, a minimum of four passes by compactor shall be applied per lift.
- For GCS installation, hand-operated compaction equipment (e.g., lightweight mechanical tampers, vibratory plates, rollers) is required within 3 ft. of the back of the end bent/abutment to ensure that backfill is in direct contact with recycled tire derivatives. Recycled tire derivatives are compacted to ensure the gap between the end bent/abutment and GCS structure are always filled by recycled tire derivatives.

Section 6 Conclusions

Results of a new test method for identifying alternative materials that have quasi-stable elastic properties similar to those of elasticized geofoam were developed and presented. Our testing evaluated seven different recycled tire derivatives and compared their performance to elasticized geofoam. Key findings are presented below.

- Shredded Tire Chip 1 performed the best in terms of recoverable deformation. Its recoverable deformation was 4.98% at a predefined strain of 15%. Under the same strain elasticized geofoam had a recoverable deformation of 4.48%. Conversely, the resistant stress of Shredded Tire Chip 1 was 4.55 psi at a predefined strain of 15%, significantly less (41.67%) than the 7.80 psi of elasticized geofoam at same strain. This may limit its use where large resistant stress is needed.

- Accounting for both recoverable deformation and maximum resistant stress Granule Recycled Tire Particle 09 – 18 exhibited the best performance at a predefined strain of 15%. Its maximum resistant stress reached 8.37 psi — 7.3% greater than the 7.80 psi of elasticized geofoam. Its recoverable deformation was 3.72%, or 17% less than the 4.48% measured for elasticized geofoam. This recycled tire derivative may be the best low-cost alternative to elasticized geofoam.

Installing chips/particles on construction sites is the biggest challenge associated with using alternative materials. To address this issue we proposed two installation methods.

- Method 1 is used for bagged recycled tire derivatives. These derivatives are stacked against the back of the end bent/abutment and placed inside of geotextile reinforcement. Granular backfill material is then spread. The lift is compacted with a suitable compactor until there is no visible sign of further settlement. Each lift (i.e., layer) consisting of bagged and wrapped tire derivatives and backfill must not exceed one (1) foot.

- Method 2 is used for bulk-packed recycled tire derivatives. Chips/particles are placed in foldout baskets located against the back of the end bent/abutment. Granular backfill material is then spread and enclosed with geotextile reinforcement. The lift is compacted with a suitable compactor until there is no visible sign of further settlement. Each lift (i.e., layer) consisting of wrapped baskets and granular backfill material must not exceed (1) foot.

Due to limited construction activities, no site has been identified for demonstration/verification purpose using tire derivatives. When KYTC selects a site, it will be developed, instrumented, and monitored.

References

[1] Nicholson, P.G. *Soil Improvement and Ground Modification Methods*. Butterworth-Heinemann, 2014.

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[4] Sun, C. and Graves, C. *Exploring Geosynthetically Confined Soil and Integrated End Bent,* Research report KTC-19-34/SPR14-473-1F, Kentucky Transportation Center, 2019.

Appendix A Draft Special Note for Treatment of End Bent or Abutment Backfills Using Geotextile Reinforcement and Elastic Inclusion

March 2022

I. DESCRIPTION

Geotextile Reinforced Backfill and Elastic Inclusion work shall consist of installing a recycled tire derivative and geotextile separation fabric between concrete surfaces and backfill material, in accordance with these specifications and pursuant to the manufacturer's recommendations, lines shown on the plans, or as established by the Engineer. It also entails placing Geotextile reinforcement within the granular backfill. Construction shall be in accordance with Special Provision No. 69, Embankment at End Bent Structures, Standard Drawing RGX-100, and Standard Drawing RGX-105, except where the requirements of this note stipulate otherwise.

II. MATERIALS

(a) **Geotextile Reinforcement:** The Geotextile Reinforcement utilized in the backfill shall be a woven fabric that meets the requirements for Class 1 High Strength Geotextile Fabric of Section 843 of the Standard Specifications, except that the Geotextile Reinforcement shall have a minimum Ultimate Strength of 1350 lb/ft and a minimum Strength at 2% strain of 380 lb/ft when tested by ASTM D 4595.

(b) **Recycled Tire Derivatives:** The recycled tire granules shall have size range between 0.0394 in. and 0.0862 in. Recycled shredded tire chips shall have size range between 2.5 in. and 5.5 in. Both can be bagged or bulk packed. The thickness of the inclusion shall be a minimum 10 times the Design Compression.

(c) **Granular Backfill:** Granular backfill material shall be crushed stone that meets the requirements of Section 805 of the Standard Specifications and conforms to the following gradation:

Sieve Size	**Percent Passing**
1-1/2 inch	100%
No. 4	0 – 25%
No. 8	0 – 5%.

III. PROCEDURES

(a) **Method 1: Stack Bagged Materials Wrapped in Geotextile Reinforcement with Granular Backfill:** Place geotextile reinforcement where the granular backfill material will meet embankment material in accordance with Section 214 of the Standard Specifications. Stack bagged shredded tire chips or recycled tire granules and granular backfill as shown in Figure 1 in lifts not to exceed 1 foot. The geotextile reinforcement shall be placed so that the strongest direction is perpendicular to the end bent/abutment and laid so that it is taut and free of wrinkles prior to backfilling. Bagged recycled tire derivatives are stacked against the back of the end bent/abutment and within the geotextile wrap. The granular backfill material shall be placed and spread starting at the bagged recycled tire derivatives and moving perpendicularly away from the end bent/abutment so that the geotextile reinforcement does not become wrinkled or develop slack. Each lift of the bagged recycled tire derivatives and backfill material shall be compacted using a suitable compactor until there is no visible sign of further compression. A minimum of four passes shall be applied per lift. Hand-operated compaction equipment, such as lightweight mechanical tampers, vibratory plates, or rollers, are required within 3 feet of the back of the end bent/abutment.

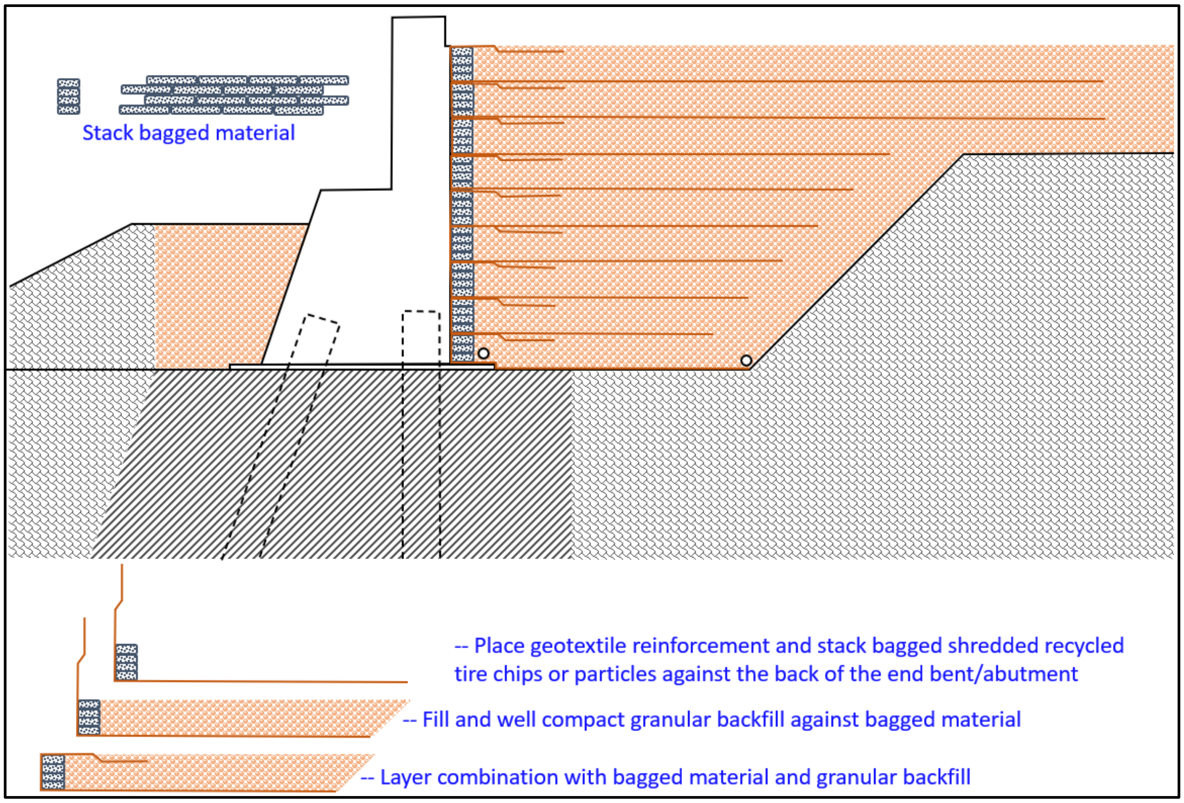


Figure 1 Method 1 — Installing and Securing Bagged Materials

(b) **Method 2: Dumping Materials in Foldout Baskets with Wrapped Granular Backfill in Geotextile Reinforcement:** Place foldout baskets against the back of the end bent/abutment. Fill foldout baskets with recycled tire derivatives and place geotextile reinforcement where the granular backfill material will meet embankment material in accordance with Section 214 of the Standard Specifications. Granular backfill material shall be completely wrapped with Geotextile Fabric Class 1 as shown in Figure 2 in lifts not to exceed 1 foot. The geotextile reinforcement shall be placed so that the strongest direction is perpendicular to the end bent/abutment and laid so that it is taut and free of wrinkles prior to backfilling. The basketed recycled tire derivatives are compacted against the back of the end bent/abutment and outside of the geotextile wrap. After placing geotextile reinforcement, the granular backfill material shall be placed and spread starting at the basketed recycled tire derivatives and moving perpendicularly away from the end bent/abutment so that the geotextile reinforcement does not become wrinkled or develop slack. Each lift of the basketed recycled tire derivatives and backfill material shall be compacted using a suitable compactor until there is no visible sign of further compression. A minimum of four passes shall be applied per lift. Hand-operated compaction equipment, such as lightweight mechanical tampers, vibratory plates, or rollers, are required within 3 feet of the back of the end bent/abutment.

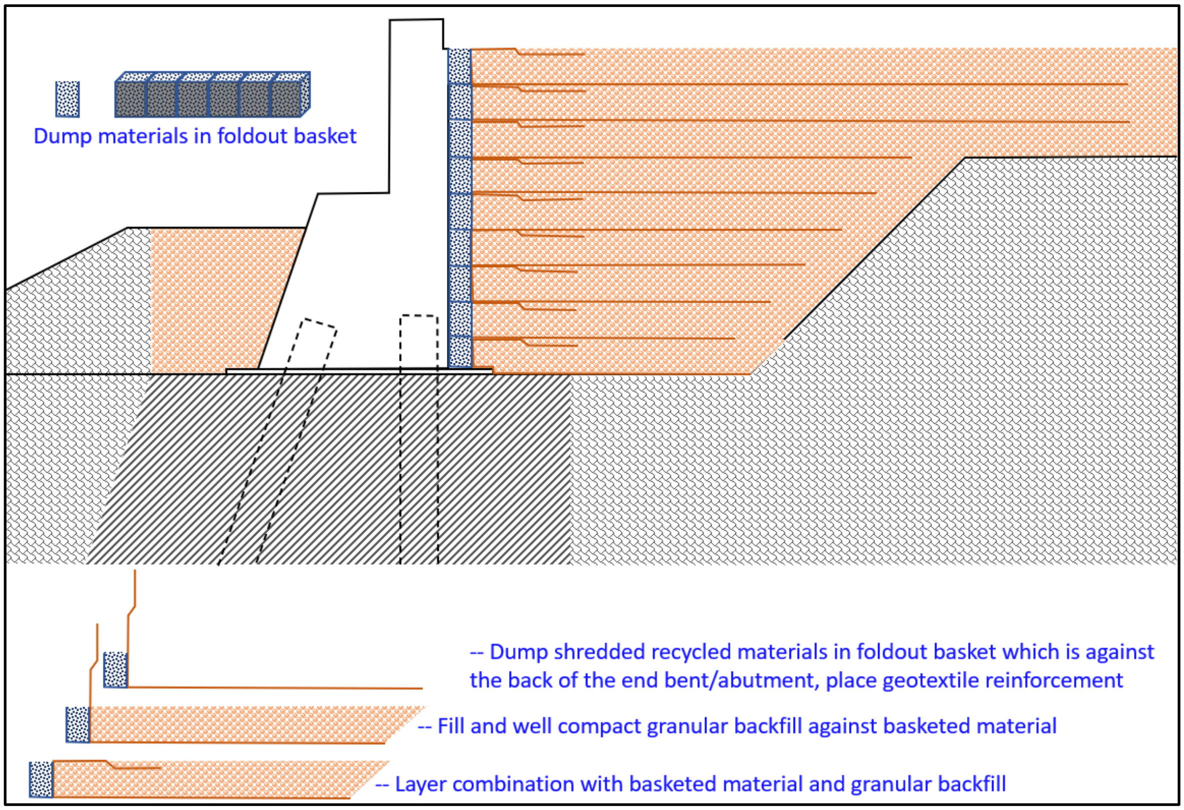


Figure 2 Method 2 — Installing and Securing Basketed Materials

IV. TESTING

Recycled tire derivatives shall be tested by an independent commercial laboratory to verify the material requirements specified herein. The Contractor shall provide written documentation of all tests specified. Documentation shall include style, lot, roll numbers, and the actual results of each test. In addition, the name, address, phone number of the testing laboratory, and date of testing shall be provided.

Geotextile reinforcement and geomembranes shall be tested by an independent commercial laboratory to verify the material requirements specified herein. The Contractor shall provide written documentation of all tests specified. Documentation shall include style, lot, roll numbers, and the actual results of each test. In addition, the name, address, phone number of the testing laboratory, and date of testing shall be provided.

V. MEASUREMENT AND PAYMENT

Recycled tire derivatives shall be measured in cubic yards along the back of backwall surface area, complete-in-place, and shall be paid for at the contract unit price per cubic yard. This price shall be full compensation for furnishing and installing the recycled tire derivatives in accordance with these Specifications for testing and for all material, labor, tools, equipment, and incidentals necessary to complete the work.

Granular backfill shall be measured in cubic yards using the plan quantity and increased or decreased by authorized adjustments as specified in Section 204 of the Standard Specifications. The Department shall not measure for payment any granular backfill not called for in the plans. The Department shall not measure for payment the 4-inch perforated underdrain pipe and shall consider it incidental to the granular backfill.

Geotextile reinforcement and Geotextile Fabric Class 1 shall be measured as specified in Section 214 of the Standard Specifications.

Payment will be made under:

Pay Item	**Pay Unit**
Recycled Tire Derivatives	Cubic Yard
Geotextile Reinforcement	Square Yard
Granular Backfill	Cubic Yard

Appendix B *Special Provision No. 69 Embankment at Bridge End Bent Structures*

SPECIAL PROVISION NO. 69
EMBANKMENT AT BRIDGE END BENT STRUCTURES

This Special Provision will apply when indicated on the plans or in the proposal. Section references herein are to the Department's Standard Specifications for Road and Bridge Construction, Current Edition.

1.0. DESCRIPTION. Construct a soil, granular, or rock embankment with soil, granular or cohesive pile core and place structure granular backfill, as the Plans require. Construct the embankment according to the requirements of this Special Provision, the Plans, Standard Drawing RGX 100 and 105, and the Standard Specifications, Current Edition.

2.0. MATERIALS.

2.1 Granular Embankment. Conform to Subsection 805.10. When Granular Embankment materials are erodible or unstable according to Subsection 805.03.04, use the Special Construction Methods found in 3.2 of the Special Provision.

2.2 Rock Embankment. Provide durable rock from roadway excavation that consists principally of Unweathered Limestone, Durable Shale (SDI equal to or greater than 95 according to KM 64-513), or Durable Sandstone.

2.3 Pile Core. Provide a pile core in the area of the embankments where deep foundations are to be installed unless otherwise specified. The Pile Core is the zone indicated on Standard Drawings RGX 100 and 105 designated as Pile Core. Material control of the pile core area during embankment construction is always required. Proper Pile Core construction is required for installation of foundation elements such as drilled or driven piles or drilled shafts. The type of material used to construct the pile core is as directed in the plans or below. Typically, the pile core area will be constructed from the same material used to construct the surrounding embankment. Pile Core can be classified as one of three types:

A) Pile Core - Conform to Section 206 of the Standard Specifications. Provide pile core material consisting of the same material as the adjacent embankment except the material in the pile core area shall be free of boulders or particle sizes larger than 4 inches in any dimension or any other obstructions that may hinder pile driving operations. If the pile core material hinders pile driving operations, take the appropriate means necessary to reach the required pile tip elevation, at no expense to the Department.

B) Granular Pile Core. Granular pile core is required only when specified in the plans. Select a gradation of durable rock to facilitate pile driving that conforms to Subsection 805.11. If granular pile core material hinders pile driving operations, take appropriate means necessary to reach the required pile tip elevation, at no expense to the Department.

C) Cohesive Pile Core. Cohesive Pile Core is required only when specified in the plans. Conform to Section 206 of the Standard Specifications and use soil with at least 50 percent passing a No. 4 sieve having a minimum Plasticity Index (PI) of 10. In addition, keep the cohesive pile core free of boulders, larger than 4 inches in any dimension, or any other obstructions, which would interfere with drilling operations. If cohesive pile core material interferes with drilling operations, take appropriate means necessary to maintain excavation stability, at no expense to the Department.

2.4 Structure Granular Backfill. Conform to Subsection 805.11

2.5 Geotextile Fabric. Conform to Type I or Class 1 in Section 214 and 843.

3.0 CONSTRUCTION.

3.1 General. Construct roadway embankments at end bents according to Section 206 and in accordance with the Special Provision, the Plans, and Standard Drawings for the full embankment section. In some instances, granular or rock embankment will be required for embankment construction for stability purposes, but this special provision does not prevent the use of soil when appropriate. Refer to the plans for specific details regarding material requirements for embankment construction.

Place and compact the pile core and structure granular backfill according to the applicable density requirements for the project. If the embankment and pile core are dissimilar materials (i.e., a granular pile core is used with a soil embankment or a cohesive pile core is used with a granular embankment), a Geotextile Fabric, Class 1, will be required between the pile core and embankment in accordance with Sections 214 and 843 of the Standard Specifications.

When granular or rock embankment is required for embankment construction, conform to the general requirements of Subsection 206.03.02 B. In addition, place the material in no greater than 2-foot loose lifts and compact with a vibrating smooth wheel roller capable of producing a minimum centrifugal force of 15 tons. Apply these requirements to the full width of the embankment for a distance of half the embankment height or 50 feet, whichever is greater, as shown on Standard Drawing RGX-105.

When using granular pile core, install 8-inch perforated underdrain pipe at or near the elevation of the original ground in the approximate locations depicted on the standard drawing, and as the Engineer directs, to ensure positive drainage of the embankment. Wrap the perforated pipe with a fabric of a type recommended by the pipe manufacturer.

After constructing the embankment, excavate for the end bent cap, drive piling, install shafts or other foundation elements, place the mortar bed, construct the end bent, and complete the embankment to finish grade according to the construction sequence shown on the Plans or Standard Drawings and as specified hereinafter.

Certain projects may require widening of existing embankments and the removal of substructures. Construct embankment according to the plans. Substructure removal shall be completed according to the plans and Section 203. Excavation may be required at the existing embankment in order to place the structure granular backfill as shown in the Standard Drawings.

After piles are driven or shafts installed (see design drawings), slope the bottom of the excavation towards the ends of the trench as noted on the plans for drainage. Using a separate pour, place concrete mortar, or any class concrete, to provide a base for forming and placing the cap. Place side forms for the end bent after the mortar has set sufficiently to support workmen and forms without being disturbed.

Install 4-inch perforated pipe in accordance with the plans and Standard Drawings. In the event slope protection extends above the elevation of the perforated pipe, extend the pipe through the slope protection.

After placing the end bent cap and achieving required concrete cylinder strengths, remove adjacent forms and fill the excavation with compacted structure granular backfill material (maximum 1’ loose lifts) to the level of the berm prior to placing beams for the bridge. Place Class 1 geotextile fabric between embankment material and structure granular backfill. After completing the end bent backwall, or after completing the span end wall, place the compacted structure granular backfill (maximum 1’ loose lifts) to subgrade elevation. If the original excavation is enlarged, fill the entire volume with compacted structure granular backfill (maximum 1’ loose lifts) at no expense to the Department. Do not place backfill before removing adjacent form work. Place structure granular backfill material in trench ditches at the ends of the excavation. Place Geotextile Fabric, Class 1 over the surface of the compacted structure granular backfill prior to placing aggregate base course.

Tamp the backfill with hand tampers, pneumatic tampers, or other means approved by the Engineer. Thoroughly compact the backfill under the overhanging portions of the structure to ensure that the backfill is in intimate contact with the sides of the structure.

Do not apply seeding, sodding, or other vegetation to the exposed granular embankment.

3.2 Special Construction Methods. Erodible or unstable materials may erode even when protected by riprap or channel lining; use the special construction method described below when using these materials.

Use fine aggregates or friable sandstone granular embankment at "dry land" structures only. Do not use them at stream crossings or locations subject to flood waters.

For erodible or unstable materials having 50 percent or more passing the No. 4 sieve, protect with geotextile fabric. Extend the fabric from the original ground to the top of slope over the entire area of the embankment slopes on each side of, and in front of, the end bent. Cover the fabric with at least 12 inches of non-erodible material.

For erodible or unstable materials having less than 50 percent passing a No. 4 sieve, cover with at least 12 inches of non-erodible material.

Where erodible or unstable granular embankment will be protected by riprap or channel lining, place Class 1 geotextile fabric between the embankment and the specified slope protection.

4.0 MEASUREMENT.

4.1 Granular Embankment. The Department will measure the quantity in cubic yards using the plan quantity, increased or decreased by authorized adjustments as specified in Section 204. The Department will not measure for payment any Granular Embankment that is not called for in the plans.

The Department will not measure for payment any special construction caused by using erodible or unstable materials and will consider it incidental to the Granular Embankment regardless of whether the erodible or unstable material was specified or permitted.

4.2 Rock Embankment. The Department will not measure for payment any rock embankment and will consider it incidental to roadway excavation or embankment in place, as applicable. Rock embankments will be constructed using granular embankment on projects where there is no available rock present within the excavation limits of the project.

4.3 Pile Core. Pile core will be measured and paid under roadway excavation or embankment in place, as applicable. The Department will not measure the pile core for separate payment. The Department will not measure for payment the 8-inch perforated underdrain pipe and will consider it incidental to the Pile Core.

4.4 Structure Granular Backfill. The Department will measure the quantity in cubic yards using the plan quantity, increased or decreased by authorized adjustments as specified in Section 204. The Department will not measure any additional material required for backfill outside the limits shown on the Plans and Standard Drawings for payment and will consider it incidental to the work.

The Department will not measure for payment the 4-inch perforated underdrain pipe and will consider it incidental to the Structure Granular Backfill.

4.5 Geotextile Fabric. The Department will not measure the quantity of fabric used for separating dissimilar materials when constructing the embankment and pile core and will consider it incidental to embankment construction.

The Department will not measure for payment the Geotextile Fabric used to separate the Structure Granular Backfill from the embankment and aggregate base course and will consider it incidental to Structure Granular Backfill.

The Department will not measure for payment the Geotextile Fabric required for construction with erodible or unstable materials and will consider it incidental to embankment construction.

4.6 End Bent. The Department will measure the quantities according to the Contract. The Department will not measure furnishing and placing the 2-inch mortar or concrete bed for payment and will consider it incidental to the end bent construction.

4.7 Structure Excavation. The Department will not measure structure excavation on new embankments for payment and will consider it incidental to the Structure Granular Backfill or Concrete as applicable.

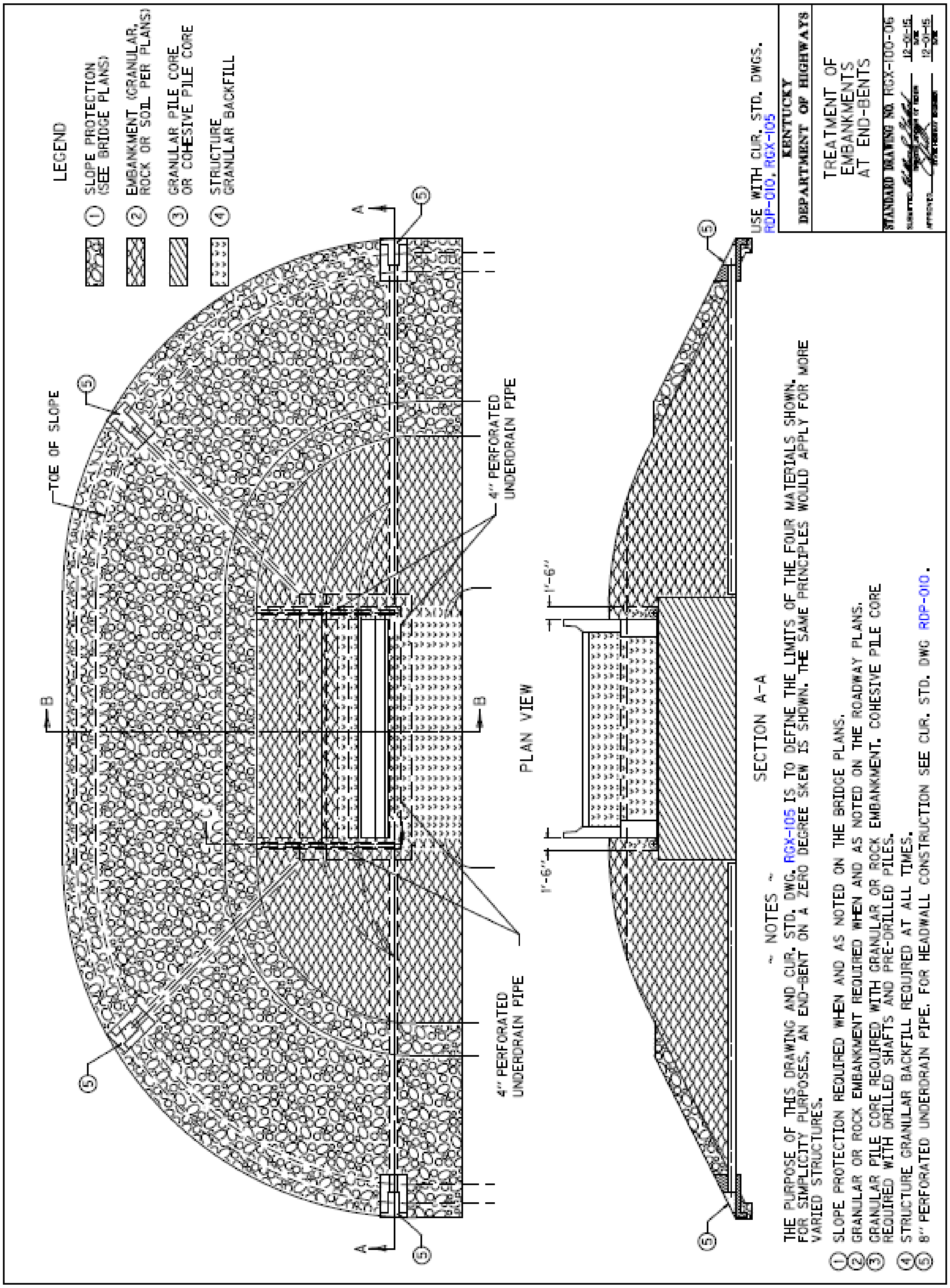
5.0 PAYMENT. The Department will make payment for the completed and accepted quantities under the following:

Code	**Pay Item**	**Pay Unit**
02223	Granular Embankment	Cubic Yards
02231	Structure Granular Backfill	Cubic Yards

The Department will consider payment as full compensation for all work required in this provision.

September 16, 2016

Appendix C Standard Drawing No. Rgx-100-06 Treatment of Embankments at End-Bents



Appendix D Standard Drawing No. Rgx-105-08 Treatment of Embankments – Details