El Paso Embankment Fill with Tire Shreds

In 1996, the Texas Natural Resource Conservation Commission (TNRCC), now the Texas Commission on Environmental Quality (TCEQ), asked TxDOT to help find an end-use for scrap tires accumulating in El Paso. TxDOT agreed to construct an experimental embankment using tire shreds as a fill material, and TNRCC agreed to pay for shredding scrap tires to TxDOT specifications. The El Paso project was the first tire-shred embankment built in Texas and the first in the nation to compare two methods of construction.

Project overview

In July 1998, TxDOT constructed two embankments on the Loop 375 overpass in El Paso using approximately 4,500 tons of tire shreds as fill material, behind earth retaining structures. Loop 375 crosses over Alcan, Dyer, McCombs and Bomarc streets. For this project, TxDOT used Special Specification Item 5160, "Tires For Use In Embankment [pdf 4 pages, 9 kb]."

One embankment, located on the east of Dyer street, consisted of 100 percent shredded tires, maximum size of 12-inch shreds, enclosed in a geotextile wrap – much like a burrito – and covered with compacted soil. The unit weight of this size uncompacted tire shreds is 22 lbs/cubic ft. This embankment used 4,895 cubic meters of tire shreds with 6,192 cubic meters of embankment material.

The total size of the embankment was 80.7-ft (24.6 m) wide and 26.6-ft (8 m) high. The area in the center of the embankment filled with the "burrito" of shredded-tire fill material placed was 48-ft (14.6 m) wide and 5.4-ft (1.8 m) deep.

Crews spread the shredded tires with track-mounted bulldozers and compacted them with a sheep's-foot roller the full width of the shredded-tire section in six 12-in. (300 mm) thick lifts. They placed an additional 14-in. (36 cm) thick layer of shredded tires on the top of the embankment to compensate for the settlement due to the placement of the overlying soil.

They covered the shredded-tire section with geotextile allowing a minimum overlap of 18 in. (450 mm) between the sheets of the geotextile wrap. The design confined the "burrito" with 16 ft (5 m) of compacted soil on each side and under a 13.2 ft (4 m) soil cap.

The second embankment type, located on the west side of Dyer Street and the west side of Bomarc Street, consisted of a 50:50 mix of soil and shredded tires, also capped with compacted soil. This embankment contained a maximum tire-shred size of four inches. Unit weight for the uncompacted tire shreds was 25 lbs/cubic ft. Crews blended 5,802 cubic meters of tire shreds with 13,120 cubic meters of embankment material.

The total size of this embankment with the tire shred/soil mix was 80.7-ft (24.6 m) wide and 26.2-ft (8 m) high. The size of the tire shred/soil mix section was 48-ft (14.6 m) wide and 6.6-ft (2 m) high. Crews spread the tire shred/soil mix in seven 12-in. lifts, subjecting each one to nonvibratory compaction.

After compaction of the seventh lift, crews placed on top and compacted an additional 16-in. (40 cm) layer of tire shred/soil mix. They excavated a trench around the embankment to construct retaining wall footing.

The third embankment type consisted of conventional soil fill 88.3-ft (26.9 m) wide and 19.7-ft (6 m) high. Crews placed the fill material in approximately 12-in. (300 mm) thick lifts.

Researchers from the University of Texas at El Paso (UTEP) evaluated constructability and short- and long-term performance. UTEP researchers installed instrumentation to obtain settlement, leachate, and temperature data for short- and long-term evaluation. Researchers at Texas Tech University evaluated costs.

Test data

UTEP researchers installed monitoring devices at each embankment to measure vertical settlement with horizontal inclinometers and magnetic extensometers, temperature variation with a system of thermocouples, leachate with a sump pump, and air quality with air ducts.

The researchers found that the settlements for the 100-percent shredded-tire embankment and the tire shred/soil mix were less than expected. The 100-percent shredded-tire embankment had a maximum settlement of 1 inch and the tire shred/soil mix embankment had a maximum settlement of 0.8 inch, both of which are minimal. This settlement occurred during eight months of construction.

No significant temperature elevations occurred within either embankment. Test results also indicated that the ambient temperature impacted the tire shred/soil mix embankment less than it impacted the 100-percent shredded-tire embankment.

Researchers did not compare leachate from the embankment types because no water percolated down to the sump.

Table 1. Burrito Tire Shred Gradation*

Sieve Size	Percent Passing
300 mm (12")	100% min
200 mm (8")	75% min
37.5 mm (1.5")	100% min
4.75 mm (No. 4)	1% max

*Exposed steel and crumb rubber should not exceed 1 percent by weight. Shreds must be free of any contaminant, such as oil or gasoline.

Table 2. 50/50 Soil-Tire Mix Tire Shred Gradation**

Sieve Size	Percent Passing
100 mm (4")	100% min
75 mm (3")	95% min
50 mm (2")	50% min
4.75 mm (No. 4)	15% max

**Exposed steel should not exceed 1 percent by mass of the shredded tires.

Results

The tire shred embankment in El Paso appears to be functioning without problems.

Researchers considered TxDOT's costs high for using the tire shreds in the embankment, coming in at more than double the costs of using traditional fill materials. These costs were due to a 30-mile haul distance to bring the shreds to the project site, at a cost of $3.16/cubic meter, and the contractor's lack of familiarity regarding the compaction effort of tire shreds. Better understanding of this material and planning may reduce these costs in future projects.

Table 3. Cost Comparison of Embankment Fill Used in TxDOT's El Paso District

Embankment Material	Construction cost per cubic meter
100% tire shreds	$11.62

50:50 tire-soil mix	$9.60
Conventional soil	$5.00

It is important to note that these cost figures do not include expenditures by the TNRCC, which totaled more than $600,000 to transport, shred, and provide security for the 4,500 tons of tire shreds used on the project. It is also important to note that tire as a fill material have the potential to improve construction results if the embankment project has a problem with weak foundation soils or a potential for slope slide failures. If a project needs the properties of tire shreds—lightweight, free-draining, low-pressure, and durable— then tire shreds may be less expensive than alternatives that address the same problems.

To maintain the construction schedule, crews placed the conventional soil fill on top of the shredded-tire section and compacted it before placing conventional soil fill as side constraints. As soon as crews placed the first line of retaining wall panels, they placed conventional fill material between the shredded-tire section and the retaining walls. Then they covered the wrapped shredded-tires section with about a foot of conventional fill.

Due to the lack of side constraint, the shredded-tire wrap became flatter and wider than intended. This significantly reduced the settlement but, also, somewhat diminished the advantages of a lightweight fill and increased the quantity of shredded tires used in the project.

A more effective process may be as follows. Construct the retaining wall to a level slightly higher than the proposed height of the shredded tire wrap. Then, place the geotextile to separate the shredded-tire section. Construct the tire wrap constrained by the two side sections. Wrap the compacted shredded tire section with the geotextile. Proceed with the rest of the construction, covering the shredded-tire section with conventional fill material until reaching the final grade elevation. The proposed construction guidelines ensure side confinement to achieve the desired compaction by rearranging the shredded tires. Fewer roller passes will achieve consistent levels of compaction. In addition, the shredded tire section will be stronger with less void spaces from rearranging tire shreds.

Stringent construction quality control and a better enforcing mechanism for the proposed specifications are also desirable. Although the specifications proposed by TxDOT suggest that the shredded tires should not be longer than 12 inches, whole tires were observed during the compaction of the shredded tires. These tires were typically shredded but held together by the steel wires.

The construction specifications suggest that no exposed steel wire should be in the tire shreds, and no soil should be present in the 100-percent shredded-tire section. The geotextile wrap should fully separate the tire-shred section from the conventional fill. In reality, the construction crews did not always follow these specifications.

The University of Texas at El Paso (UTEP) researchers evaluated constructability, quality control/quality assurance procedures, instrumentation data, short- and long-term performance and cost. In addition, Recycled Materials Resource Center posted information on this project in its Virtual Demonstration Site on Tires [pdf 9 pages, 443 kb].

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