Use of Shredded Tire as Backfill for a New GRS Reinforced Retaining Wall System

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ABSTRACT: **Waste tires that have been cut into chips yield a material that is coarse grained, free draining, and has low unit weight, thus offering significant advantages for use as retaining wall backfill. The major** technical concern, however, is high compressibility. A new geosynthetic-reinforced soil (GRS) retaining wall system, referred to as the "CTI-MSB wall" has recently been developed by the Colorado Transportation Institute. One of the most important features of the wall is that the geosynthetic reinforcement is not attached to the full-height concrete facing panel; therefore, the backfill can settle substantially without causing distress in the facing panel. A well-controlled loading test was conducted to investigate the performance of the CTI-MSB wall with shredded tires as backfill. The test was conducted inside a plane strain testing facility. The test wall was three-meter high. The reinforcement was not wrapped at the face. The loading test indicated that the CTI-MSB wall **can successfully accommodate the highly compressible shredded tires as backfill.**

1 INTRODUCTION

Disposal of over two billion waste tires sit in the stockpiles across the U.S. and the estimated 240 million more discarded each year is a pressing problem. Reusing waste tires in highway applications is a viable way to ease the burden on our landfills. Waste tires that have been cut into chips yield a material that is coarse grained, free draining, and has low unit weight, thus offering significant advantages for use as retaining wall backfill. The major concern, however, is its high compressibility.

The Colorado Transportation Institute has recently developed a new geosynthetic-reinforced soil (GRS) retaining wall system referred to as the "CTI-MSB" wall (Colorado Transportation Institute Mechanically Stabilized Backfill wall). This new retaining wall system consists of four components (Wu, et al., 1993): a continuous reinforced concrete facing panel, backfill, geosynthetic reinforcement sheets (placed horizontally in backfill), and anchor rods (attaching facing panel to backfill), as shown in Figure 1. One of the most important features of the CTI-MSB wall is that the geosynthetic reinforcement is not attached to the full-height concrete facing panel; therefore, the backfill can settle substantially without causing distress in the concrete facing panel. The full-height concrete facing panel is supported by sliding/yielding anchors that are embedded in the backfill.

This paper describes a well-controlled loading test of the CTI-MSB wall using shredded tires (tire chips) as backfill, and presents some results of the loading test. The test was conducted inside a plane strain testing facility to achieve better control of the test conditions. A unique feature of this test is that the reinforcement was *not* wrapped at the face (where the backfill came in contact with the facing panel). Such a measure will reduce significantly the construction time and cost.

2 THE CTI-MSB TEST WALL

The plane strain testing facility within which the test wall was constructed has been described in detail elsewhere (Wu, 1992). The MSB test wall was 3 m high, 1.2 m wide and 2.7 m deep. The reinforced concrete facing panel was 10 cm thick. Four steel anchors of 1 cm in diameter were installed at 0.81 m and 2.46 m from the base of the wall (two at each height). Each anchor was attached to the facing

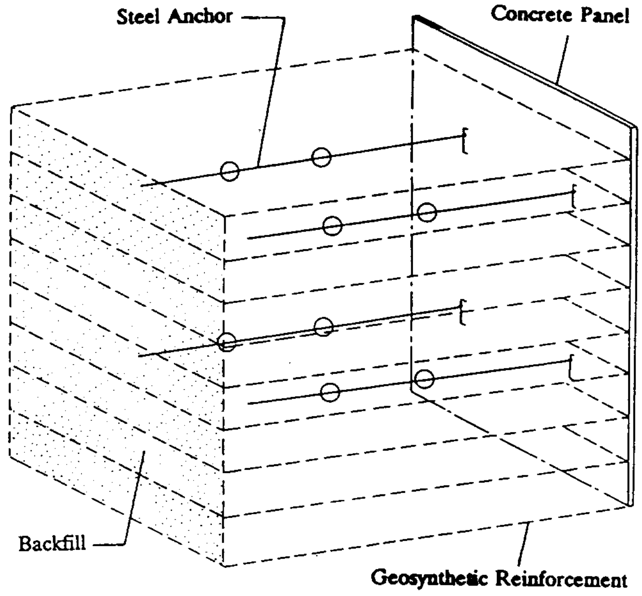

Figure 1 Schematic Diagram of the CTI MSB Wall

panel by a sliding "D-connection" (Wu, et al., 1993). The test wall was reinforced with 10 layers of geosynthetic reinforcement. The reinforcement was a heat bonded nonwoven geotextile. The reinforcement were not wrapped at the face; instead, they were simply laid horizontally in the backfill at 30 cm vertical spacings.

3 CONSTRUCTION AND LOADING SEQUENCE

The construction and loading sequence of the test wall is illustrated in Figure 2, which involves the following five steps:

Step 1 — The concrete facing panel was raised and positioned to rest on a prescribed location of the aggregate-treated floor of the testing facility. A steel strut was employed to support the front surface of the concrete panel at 0.25 m below the top of the panel.

Step 2 — Shredded tires were emplaced in 30- cm thick lifts. Each layer was compacted by "foot tamping." The average unit weight of the shredded tires after compaction was approximately 6.3 kN/m^3. Upon completing the placement of a layer of backfill, a sheet of geosynthetic reinforcement was placed horizontally on top of the layer.

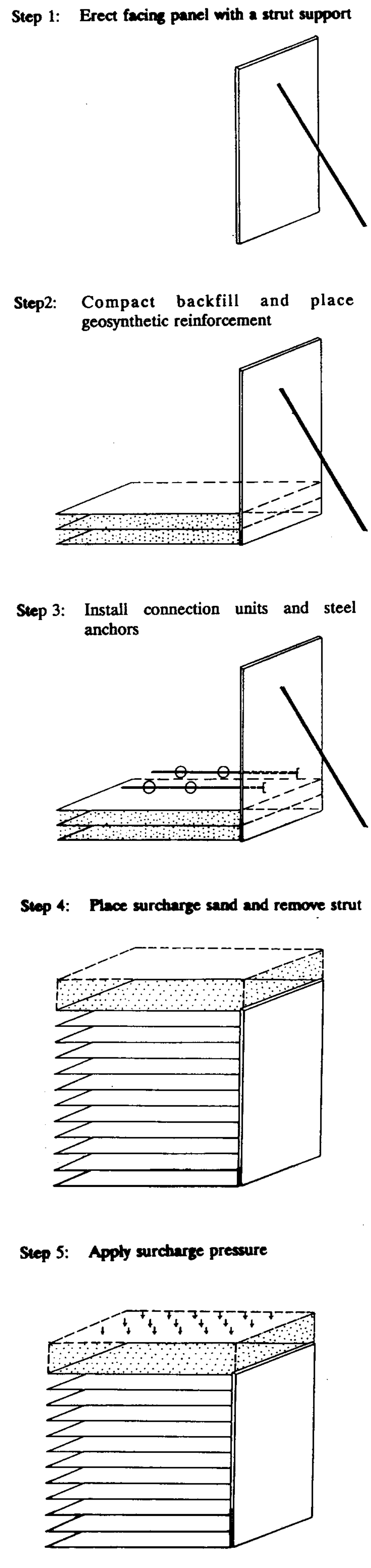

Figure 2 Construction and Loading Sequence

Step 3 Steel anchors were attached to the concrete facing panel as fill heights reached 0.81 m and 2.46 m above the base of the wall. Prior to attaching each anchor, a D-connection was installed on the back face of the panel. One end of the anchor was looped around the vertical portion of the D-connection.

Step 4 Upon reaching the full fill height, 40-cm thick of the Ottawa sand (without compaction) was placed on top of the backfill as surcharge (surcharge pressure = 7.2 kPa). Subsequently, the steel strut was removed.

Step 5 The top surface of the surcharge sand was subjected to two loading/unloading cycles of uniform pressure from 0 to 27.6 kPa. After which, surcharge pressure was applied in two increments of 27.6 kPa and 17.2 kPa, and was maintained constant thereafter (under a total surcharge of 52 kPa).

4 TEST MATERIALS

4.1 The Geosynthetic Reinforcement

The reinforcement used in the tests was a nonwoven heat-bonded polypropylene geotextile. Some relevant index properties provided by the manufacturer are listed below:

Unit weight (ASTM D-3776)	1.93 N/m^2
Grab tensile (ASTM D-4632)	890 N
Elongation at break (ASTM D-4632)	60 %
Modulus @ 10% strain (ASTM D-4632)	4.45 kN
Nominal thickness	0.508 mm

The uniaxial load-deformation behavior of the geotextile has been reported by Wu, et al. (1993). Previous tests of this geotextile has indicated that its load-extension behavior is not affected by the confining pressure (Wu, 1991).

4.2 The Shredded Tires

The shredded tires used in the test were typically 10 to 15 cm long and 5 to 7 cm wide. A one-dimensional compression test was performed on the shredded tires prepared at a unit weight of 6.3 kN/m^3. The test was conducted inside a 50-cm high steel cylinder 50 cm in diameter. The inner surface of the cylinder was lubricated by a latex membrane-silicone grease technique.

The loading history of the one-dimensional compression test included three stages. In the first stage, normal stresses were increased at a constant stress rate; a constant stress of 43 kPa was then maintained for 300 minutes in the second stage; it was finally unloaded to zero in the third stage. The stress-strain relationship in the first stage was approximately linear with constrained modulus equaled to 390 kPa. Fairly pronounced creep deformation occurred in the second stage of the test. The creep strain over the 300-minute period was about 1.3%, which accounted for about one-tenth of the total strain. The rate of creep, however, decreased very rapidly with time. At the completion of the third stage, the irrecoverable plastic strain was only about 2%, indicating that most of the strain was recovered upon unloading.

5 INSTRUMENTATION

The test wall was instrumented to monitor its behavior during construction and upon application of the surcharge pressure. The instruments used were dial indicators, extensometers, and a lubricated latex grid system, which was monitored along the plexiglass side wall to measure the internal movement of the backfill. The friction angle between the lubrication layer and plexiglass as determined by direct shear test was less than one degree (Tatsuoka, et al., 1984). Such a procedure also allow the test wall to be in a state of plane strain condition.

6 RESULTS AND DISCUSSION OF RESULTS

The displacement field of the backfill during the test is depicted in Figure 3. The lateral displacements of the shredded tires backfill were very small compared with the vertical displacements. At 52 kPa surcharge pressure, a maximum settlement of 15 cm was measured at the top surface of the backfill. The maximum creep rate in the first 20 days was approximately 0.125 cm/day. After 100 days, however, the creep rate decreased to about 0.003 cm/day. The displacements are continued to be monitored at this writing.

The movement of the concrete facing panel was small. Figure 4 shows the displacements of the concrete facing panel at two different heights under the sustained surcharge of 52 kPa. The rate of creep deformation also decreased rapidly with time.

- 7.2 kPa surcharge (after load/unload cycles)
- 34.8 kPa surcharge
- 52.0 kPa surcharge
- 20 days under 52 kPa surcharge
- 100 days under 52 kPa surcharge

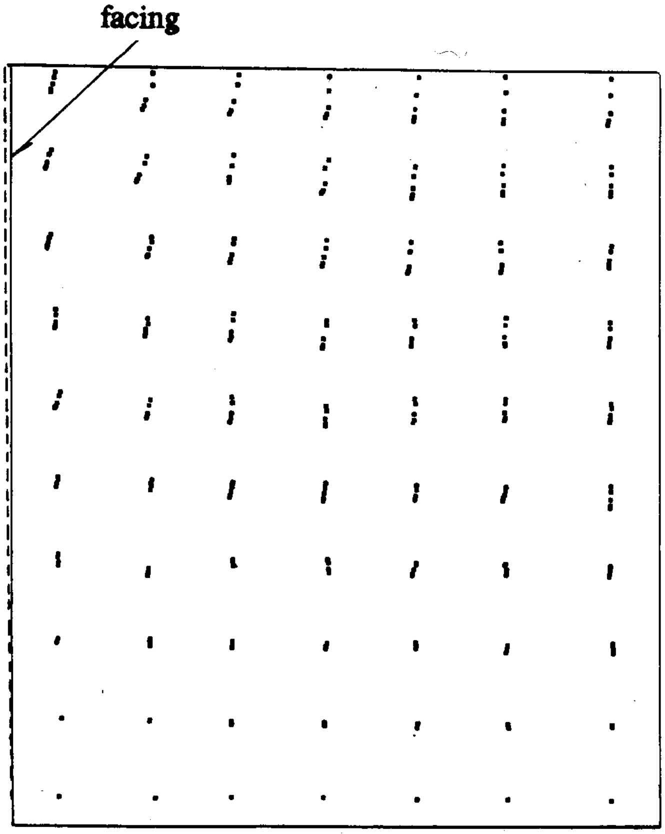

Figure 3 Displacement Field of the Shredded Tire Backfill

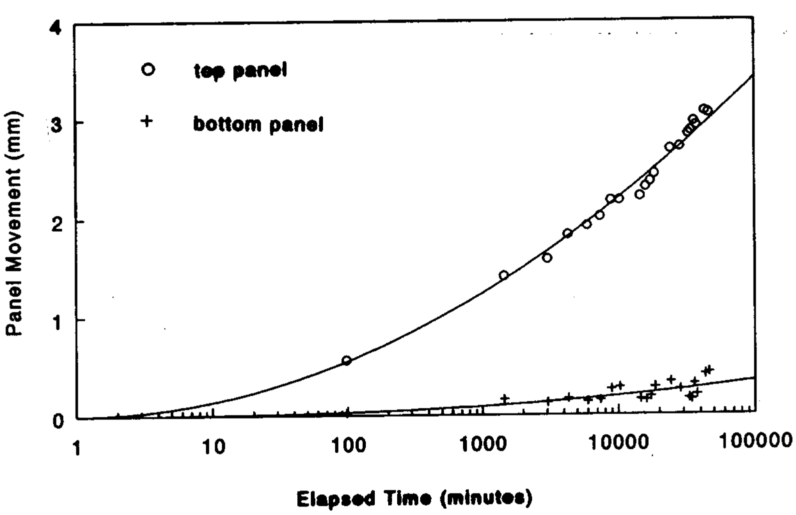

Figure 4 Movement of the Facing Panel under Sustained Surcharge of 52 kPa

7 CONCLUDING REMARKS

Under a surcharge pressure of 52 kPa, there was no sign of distress in the concrete panel. However, the "instantaneous" vertical displacement on the top surface of the shredded tire backfill was as high as 15 cm. This large vertical settlement has to be accommodated in the design and construction of retaining walls using shredded tires as backfill. The vertical creep deformation under 52 kPa surcharge pressure of was significant. However, the creep rate decreased at rapidly decreasing rate.

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