CHICAGO GRADE LANDFILL
TIRE SHRED TEST PAD

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PURPOSE

The purpose of the Chicago Grade Landfill Tire Shred Test Pad was to determine the overall constructability of a tire shred fill with an overlying soil layer using three types of tire shreds. A geotextile separation layer was used between the tire shreds and soil in some areas. Parameters that were evaluated included compactability of a one-foot thick and two-foot thick soil layer placed over the tire shreds, the need for a geosynthetic separation layer to prevent soil from migrating into the tire shreds during construction, and the survivability of the geotextile during placement and compaction of the overlying soil layer.

MATERIAL PROPERTIES

<u>Tire Shred Properties</u>

Three types of tire shreds were evaluated for this project. The Type I shreds were produced by a single pass through a Barclay shredder with a knife spacing of 6 in. The shred sizes typically ranged from 10 in. to half of a passenger tire. There was only a limited amount of steel belt exposed at the cut edges of the shreds. A photograph of a representative sample is shown in Figure 1.

The Type II shreds were produced by a single pass through a MAC Saturn model 6044 shredder owned by Chicago Grade Landfill. The shredder had a knife spacing of varying between 1-1/4 and 1-3/4 in. The shreds generally had a maximum size of 12 in., however, there were occasional shreds as long as 24 in. The shredder knives were very dull resulting in shreds with a significant amount of steel exposed at the cut edges. In some cases the steel protruded 3 in. from the cut edge. The shreds also contained a significant amount of free steel, which is defined as metal fragments that are not at least partially encased in rubber. A photograph of a representative sample is shown in Figure 2. Two samples were taken for gradation analysis. The results are shown in Figure 3. Complete test results are given in Attachment A.

The Type III shreds were produced by the same machine used to produce the Type II shreds, however, the shreds were passed over a classifier and the oversize pieces were re-shredded. This resulted in a shred with a maximum size of about 3 in. Since the shredder knives were very dull, the shreds had a significant amount of steel exposed at the cut edges as well as a significant amount of free steel. A photograph of a representative sample is shown in Figure 4. Two samples were taken for gradation. The gradation results are shown in Figure 3. Complete test results are given in Attachment A.

Figure 1. Photograph of Type I shreds.

Figure 2. Photograph of Type II shreds.

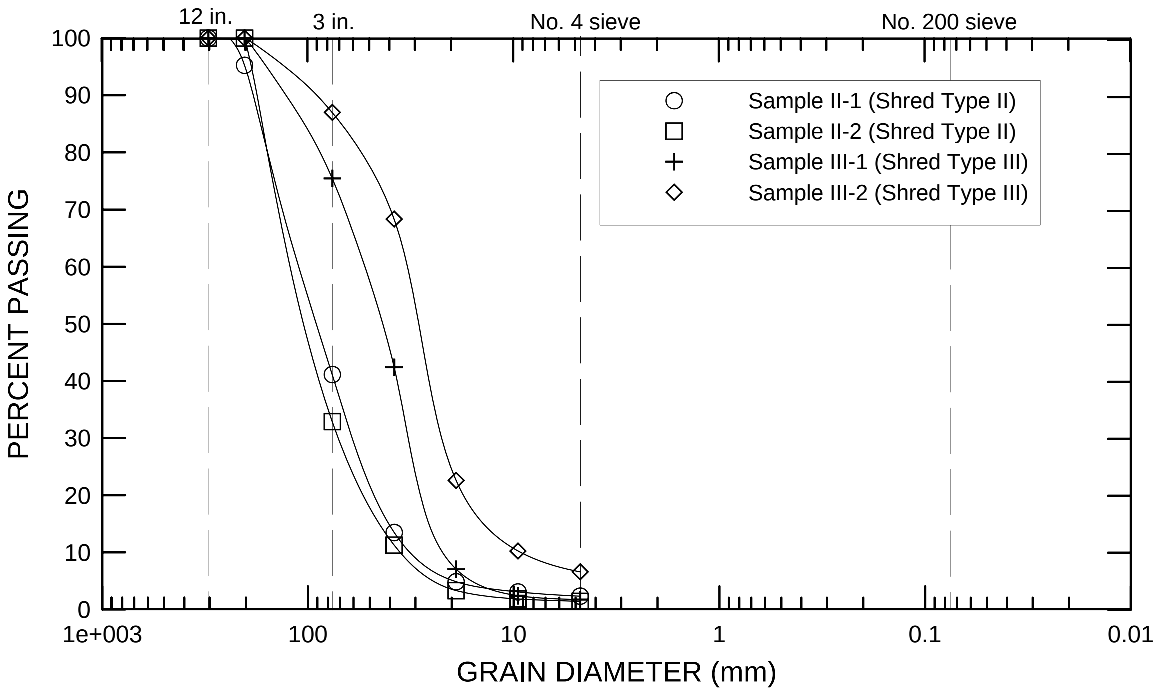

Figure 3. Gradation of Type II and III shreds.

Figure 4. Photograph of Type III shreds.

Geotextile Properties

The geotextile was required to meet the specifications given in Table 1. The requirements are a function of the elongation at failure as determined by ASTM D 4632.

Table 1. Requirements for geotextile.

Property	Elongation at failure as determined by ASTM D 4632	
	<50%	>50%
Grab Strength (ASTM D 4632)	270 lb[1]	180 lb[1]
Puncture Resistance (ASTM D 4833)	100 lb[1]	75 lb[1]
Tear Strength (ASTM D 4533)	100 lb[1]	75 lb[1]

[1]Values shown are the minimum roll average values. Strength values are in the weakest principal direction.

The geotextile provided by Chicago Grade Landfill was GEOTEX™ 1001. It is a nonwoven geotextile with a roll width of 15 ft. The roll had about 180 lineal feet of material. Proof test results provided by the manufacturer are given in Attachment B. Grab tensile tests (ASTM D 4632) were performed on ten replicate samples by TRI/Environmental, Inc., of Austin, Texas. The resulting mean tensile strength was 271 lb at an elongation at the maximum load of 76% in the machine direction and 337 lb at an elongation at the maximum load of 89% in the cross machine direction. These met the requirements for grab tensile strength given in Table 1. The complete test results as provided by TRI/Environmental are given in Attachment C.

Soil Cover

The soil placed over the tire shreds was a sandy clay with a trace of gravel. One sample was taken for laboratory testing. The results of gradation, Atterberg limit, and laboratory compaction (ASTM D1557) tests are shown in Attachment D. This sample was classified as CL according to the Unified Soil Classification System (USCS).

TEST PAD LAYOUT

The test section was divided into four areas as shown in Figure 5. Each area was 30 ft long by 20 ft wide. A 24-in. (approximate) thickness of Type I shreds was used for the first layer in each area. The type of shred used for the second 12-in. (approximate) thick layer was varied in each area. In Area 1 the second layer was Type I shreds. Type II shreds were used for the second layer in Area 2. In Areas 3 and 4, Type III shreds were

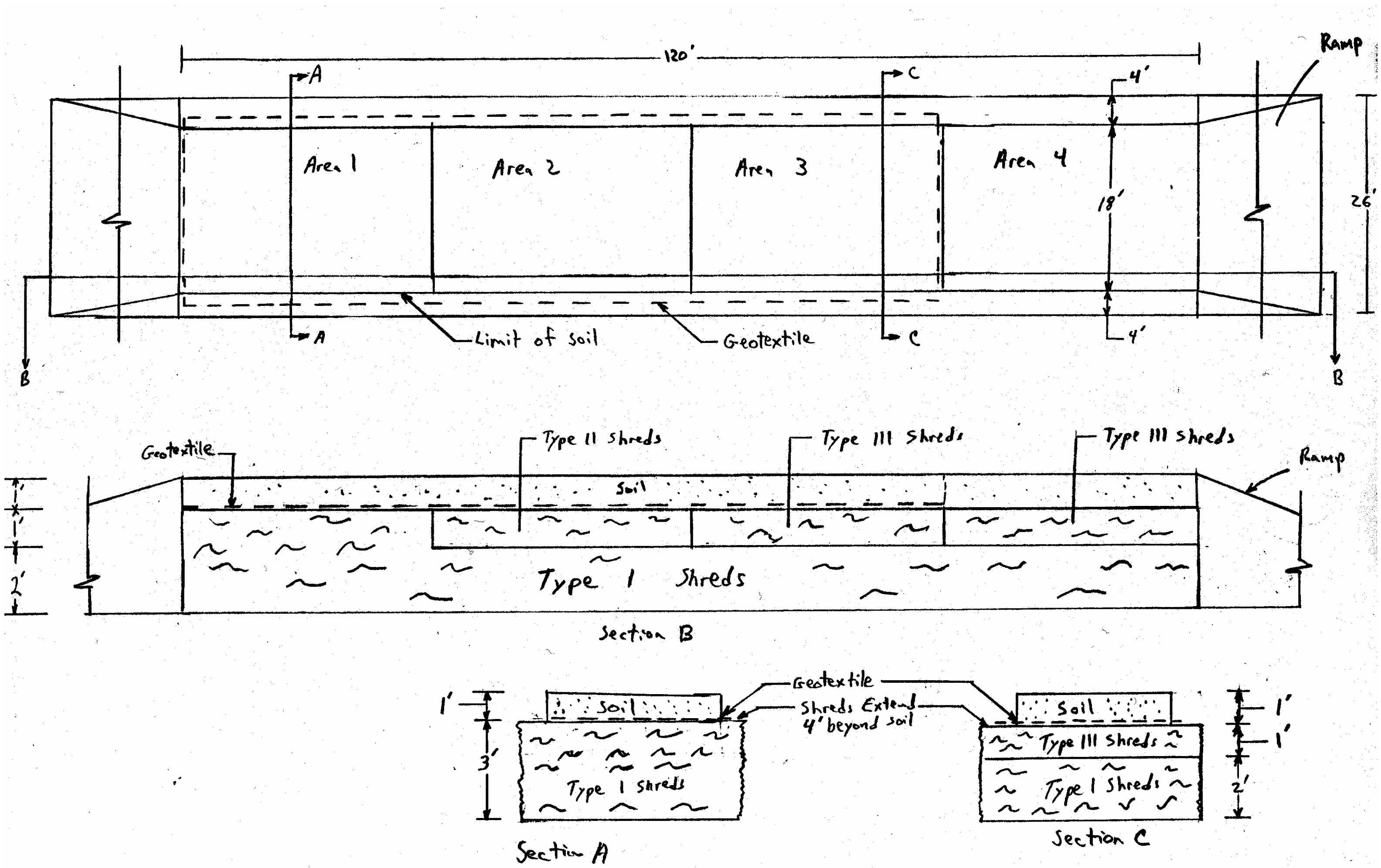

Figure 5. Sketch of test pad layout (prepared by Albert Johnson, CIWMB).

used for the second layer. The tire shreds were covered by geotextile in Areas 2 and 3. Geotextile also covered most of the surface of Area 1 as shown in Figure 5. No geotextile was used for Area 4. Each area was covered by two 12-in. (approximate) thick lifts of compacted soil. Soil was used to construct a ramp at each end of the test pad to allow for construction vehicle access.

CONSTRUCTION

The test pad was constructed on the intermediate cover on top of the landfill. The intermediate cover consisted of tire shreds overlain by soil. Prior to August 4, 1998, the initial lift of Type I shreds was placed and Types I, II, and III shreds were stockpile adjacent to the test pad. The remainder of test pad construction and evaluation occurred between August 4 and 6, 1998. The first step was to compact the previously placed Type I shreds by four passes of a Dresser TD25 bulldozer. The approximate lift thickness was measured with a hand level at two or three locations in each area. The thicknesses are summarized in Table 2.

Table 2. Approximate lift thicknesses of tire shred layers.

Area	Lower lift		Upper lift	
	Tire shred type	Lift thickness (in.)	Tire shred type	Lift thickness (in.)
1	I	23	I	13
2	I	19	II	10
3	I	21	III	11
4	I	17	III	11

Note: the lift thicknesses in each area are the average of readings taken at two or three locations.

The second layer of tire shreds was placed and leveled with a Caterpillar 966F loader. The Type II and III shreds appeared to be very loose after spreading due to interlocking of the exposed steel belts. The Type I shreds also appeared to be loose however the cause was attributed their large size and irregular shape.

The second layer was compacted by four passes of a Dresser TD25 bulldozer. By visual observation, the first tread coverage of the dozer compacted the Type I shreds between 0 and 8 in. The lower bound was for areas that were initially low and did not receive the full weight of the dozer. The Type II and III shreds were compacted 3 to 6 in. by the first tread coverage of the dozer. This is greater compaction than is normally observed with tire shreds with a maximum size similar to Type II and III shreds. This is most likely due to the low initial density of the tire shreds caused by the large amount of exposed steel belts as noted above. The approximate lift thickness in each area was measured with a hand level. An insufficient thickness had been placed in some areas so additional shreds were added where needed and the surface was recompacted with four passes of the Dresser TD25 dozer. The thicknesses of the second lift after placement of additional shreds and recompaction are shown in Table 2.

The geotextile was unrolled on the surface of the shreds in Areas 1, 2, and 3. Prior to unrolling the geotextile, spray paint was used to mark a straight line down the centerline of the test pad. This served as a guide when unrolling the first strip of geotextile. The geotextile was unrolled parallel to the centerline. A second strip of geotextile was unrolled on the other side of the centerline and was overlapped by 18 in. with the previously placed strip. Thus, there was a single overlapping seam coinciding with the longitudinal centerline of the test pad. No difficulty was encountered in unrolling the geotextile. There was insufficient geotextile to completely cover the shreds in Area 1, so a portion of this area remained uncovered by geotextile.

Soil cover was hauled from a borrow area located on site and stockpiled near the test pad. Water was added to the stockpile and blended in by mixing with a CAT 966F loader. The water content at the time of placement was estimated to be wet of its optimum water content. The soil was placed in a 12-in. thick (approximate) loose lift with a CAT 966F loader and then leveled with a Dresser TD25 bulldozer. The lift was compacted by four passes with a Dresser TD25 dozer followed by four passes with a CAT 966F loader. The compacted thickness of the first lift of soil was determined by excavating through the soil to the underlying geotextile or shreds at three or four locations in each section. The thicknesses are shown in Table 3. The second 12-in. lift of soil cover was placed and compacted in a similar manner. The approximate thicknesses of this lift, as determined with a hand level, are shown in Table 3.

Table 3. Thickness of soil cover layers and compression of tire shred layer.

Area	Soil cover lift thickness (in.)[1]		Thickness of tire shred layer (in.)[1]		Compression of tire shred layer due to placement of first soil layer
	First lift	Second lift (see note 2)	Initial	After placement of first soil lift	
1	17	9	36	21	42%
2	14	11	29	20	31%
3	12	10	32	21	34%
4	10	7	28	19	32%

Notes:
1. The thicknesses are the average of three or four measurements in each area.
2. The actual thickness of the second soil cover lift is greater than the reported value since the method of measurement did not account for compression of the underlying tire shreds due to the weight of the soil.

The compression of the tire shred layer due to the weight of the first lift of soil was determined by measuring the before and after thickness of the tire shreds with a hand level. The results are shown in Table 3. Area 1, which had Type I shreds in both layers, compressed about 42%. Areas 2, 3, and 4, which consisted of Type I shreds overlain by Type II or III shreds, compressed between 31% and 34%. These very large compressions are felt to be due to the high compressibility of the Type I rough shreds.

OBSERVED PERFORMANCE OF GEOTEXTILE

To observe performance of the geotextile and underlying tire shreds, three holes (approximately 10-in. diameter) were hand excavated in each section after placement and compaction of the first lift of soil. One hole was located right of centerline, one on centerline, and one left of centerline. A fourth hole was excavated in Area 1 to examine the portion of this area with no geotextile.

No major damage was observed in the geotextile. Although the geotextile was penetrated by belt or bead wire in three of the nine holes that encountered geotextile, the diameter of the penetration was the same as the diameter of the wire and did not result in a tear. One hole encountered the overlapping seam between the two strips of geotextile. No loss of overlap was observed.

In Area 4 there was no separating geotextile. The soil did not appear to have penetrated into the voids between the Type III shreds. However, the hole excavated in the portion of Area 1 with no geotextile revealed that the soil had penetrated at least 2 in. below the top surface of the Type I shreds. It was not possible to excavate further through the large size shreds by hand and it is likely that the soil penetrated a greater depth into the shreds.

OBSERVED PERFORMANCE OF SOIL COVER

The compacted surface of the first lift of soil contained numerous cracks as shown in Figures 6 through 9. By visual observation it appeared that Area 1 experienced the most cracking, Area 4 experienced an intermediate amount of cracking, and Areas 2 and 3 experienced the least amount of cracking. Thus, it appears that the larger Type I shreds cause more cracking than the smaller Types II and III shreds. Comparing Areas 3 and 4, it appears that the geotextile slightly reduced cracking of the first lift of soil.

The compacted surface of the second lift of soil contained significantly fewer cracks than observed in the first lift. Photographs of the soil surface in each area are shown in Figures 10 through 13. There was no discernible difference in the degree of cracking between the four areas.

Figure 6. Photograph of surface of lower soil cover lift in Area 1.

Figure 7. Photograph of surface of lower soil cover lift in Area 2.

Figure 8. Photograph of surface of lower soil cover lift in Area 3.

Figure 9. Photograph of surface of lower soil cover lift in Area 4.

Figure 10. Photograph of surface of upper soil cover lift in Area 1.

Figure 11. Photograph of surface of upper soil cover lift in Area 2.

Figure 12. Photograph of surface of upper soil cover lift in Area 3.

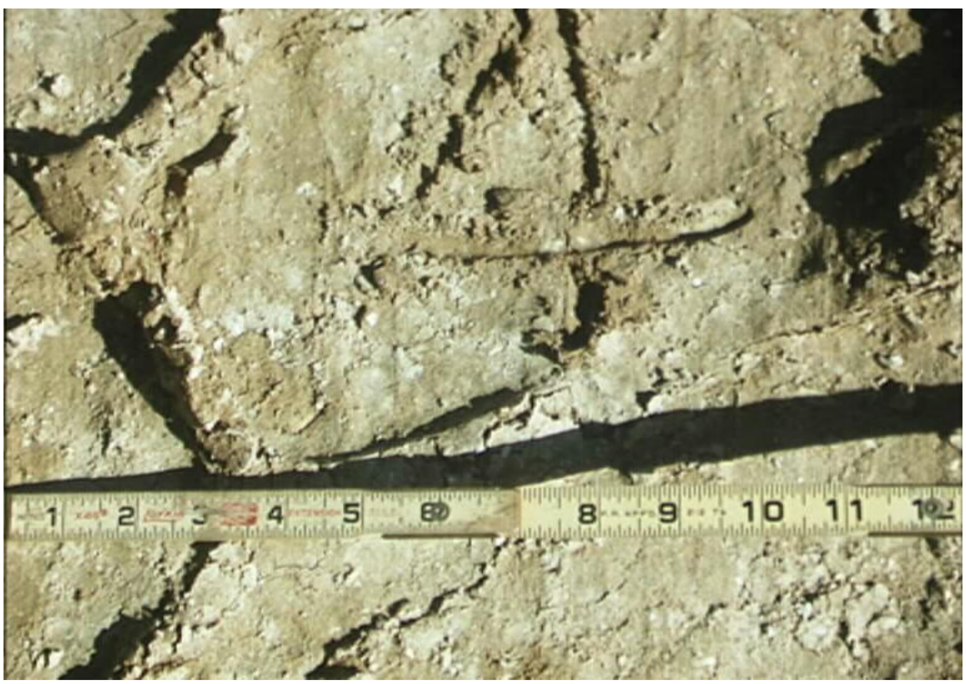

Figure 13. Photograph of surface of upper soil cover lift in Area 4.

In-place field densities were determined by the nuclear gauge method (ASTM D2922 and D3017) with the gauge set at a 10-in. depth and the sand cone method (ASTM D1556 and D2216) by S&G Testing Laboratories, Inc. Complete test results are given in Attachment E.

The percent compaction of the first (lower) lift of soil cover ranged from 84% to 88% with an average of 87%. The water content of this lift ranged from 20.5% to 24.9% (average 23.0%) which corresponds to 1.5 to 5.9 percentage points wet of optimum. Similarly, the percent compaction of the second (upper) lift ranged from 83% to 90% with an average of 87%. The water content ranged from 20.5% to 26.9% (average 23.2%) which corresponds to 1.5 to 7.9 percentage points wet of optimum. The similarity of the compaction results for the first and second lifts indicate that the percent compaction was not influenced by the compressibility of the underlying tire shreds. If this were the case, the percent compaction for the first lift would have been lower than the second lift. Thus, the percent compaction appeared to be limited by the type of compaction equipment used and the soil being several percentage points wet of optimum.

The sand cone method was used to provide a basis for comparison to determine if the nuclear gauge method could accurately determine the density and moisture content of soil underlain by tire shreds. The uncertainty with the nuclear gauge method is that the moisture content measured by the gauge could be influenced by the hydrogen in the rubber of the underlying tires. Sand cone and nuclear test results taken at the same locations are compared in Table 4. The average water content of the lower lift was 24.1% by the nuclear gauge method compared to 21.3% by the sand cone method. Thus, it appears that the moisture content measured by the nuclear gage was influence by the underlying tire shreds. For the upper lift, the average water content was 23.7% by the nuclear gauge versus 22.7% by the sand cone. A difference of this magnitude could be due to scatter of the data. These results suggest that the nuclear gage method should not be used to determine the moisture content of the first lift of soil placed over tire shreds.

Table 4. Comparison of field density test results using the sand cone and nuclear.

Lift	Location	Nuclear Gauge		Sand Cone	
		Water content (%)	Dry unit weight (pcf)	Water content (%)	Dry unit weight (pcf)
Lower	Center-northwest	23.2	94.8	20.5	95.0
Lower	North-Center	24.9	91.9	22.0	92.7
Lower	**Average**	**24.1**	**93.4**	**21.3**	**93.9**
Upper	South end-center	22.6	91.9	23.5	95.7
Upper	North end-west	23.1	92.6	22.0	96.3
Upper	South end-center	26.9	88.8	24.7	91.4
Upper	North end-west	22.2	94.4	20.5	97.2
Upper	**Average**	**23.7**	**91.9**	**22.7**	**95.2**

Comparing the dry densities determined by the nuclear gage and sand cone methods at each test location (see Table 4), the densities differ by 0.2 to 3.8 pcf with the sand cone consistently giving a higher density. This could be due to inaccuracies in the two test methods.

SUMMARY

The Chicago Grade Landfill Tire Shred Test Pad was constructed to determine the overall constructability of a tire shred fill with an overlying layer of compacted clay using rough shreds (Type I), shreds with a maximum size of 12 in. (Type II), and shreds with a maximum size of 3 in. (Type III).

Geotextile was used as a separator between the tire shreds and soil in some areas. After placement and compaction of the overlying soil, no significant damage to the geotextile was observed. Thus, the geotextile was strong enough to resist damage during construction. In the area with no geotextile, there was significant penetration of soil into the larger Type I shred, so a geotextile separator is desirable with larger size shreds. The area with smaller Type III shreds and no geotextile had little penetration of soil into the shreds, none the less, a geotextile separator may be desirable to prevent migration of soil into the shreds for long term conditions.

The first 12-in. lift of overlying soil cover contained numerous cracks. The compressibility of the larger Type I shreds tended to produce more cracks than the smaller Types II and III shreds. The presence of a geotextile separator slightly reduced cracking, however, the effect was small. The second 12-in. lift of soil cover contained significantly fewer cracks than the first lift. None the less, the cracking of the second layer was probably sufficient to increase its permeability. This illustrates the difficulty of placing a low permeability compacted soil layer over tire shreds.

The tire shred layers were compressed between 31 and 42% by the weight of the first layer of soil. This shows the high compressibility of larger Type I shreds.

The compacted density of the soil cover appeared to be limited by the compaction equipment used and the water content of the soil being several percentage points wet of optimum. For the conditions encountered in this project, the compressibility of the tire shreds did not appear to limit the compactability of the soil cover.

For the lower soil layer, the nuclear gage method gave a higher water content than the sand cone method. The difference is probably caused by the influence of the hydrogen in the underlying rubber on the water content reading from the nuclear gage. Thus, a nuclear gage should not be used to determine the water content of the first lift of soil over tire shreds.

LIMITATIONS

This report was prepared in general accordance with accepted engineering practice. The professional opinions and recommendations expressed in this report are based on limited knowledge of the performance of tire shreds in engineering projects. Judgements leading to conclusions and recommendations are generally made with an incomplete knowledge of the conditions present. No other representations, expressed or implied, and no warranty or guarantee is included or intended.

This report may be used only by the Client and only for the purposes stated, within a reasonable time from its issuance. Non-compliance with any of these requirements by the Client or anyone else will release Dana N. Humphrey, Consulting Engineer, from any liability resulting from the use of this report.

Attachment A
Tire Shred Gradation Test Results

Attachment B
Geotextile Proof Test Results
Provided by Manufacturer

Attachment C
Geotextile Grab Tensile Test Results

Attachment D
Laboratory Test Results
for Soil Cover

Attachment E
In-Place Field Density Test Results
for Soil Cover