MATERIALS & RESEARCH DIVISION

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RESEARCH UPDATE

Number U91-5

USE OF TIRE CHIPS IN A HIGHWAY EMBANKMENT

HISTORY:

Vermont's solid waste management plan estimates that 200,000 used tires are discarded annually in Vermont, placing a high demand on valuable landfill space. One proposal to reduce this component of the waste stream is the placement of chipped tires in highway embankments as an environmentally appropriate alternative to landfilling tires. In order to evaluate the feasibility of this proposal, tire chips were used for a portion of the earth borrow necessary to flatten a highway side slope.

Project RS000S(12), section (site) 6227, in the Town of Middlesex, Hamlet of Putnamville, was chosen. The project objective was to eliminate the need for guardrail, by removing existing two cable guardrail and flattening the side slope from 1 on 1.5 to 1 on 3.

INSTALLATION:

Between September 10 and September 24, 1990, 2738 cubic yards (cy) of shredded tires were placed as side slope fill. Extension of a 48" culvert and site preparation had previously been accomplished.

Large volumes of chips could be moved in a short time since the uncompacted chips are much lighter than rock or earth fill. Consolidated chips had a steep unsupported angle of repose. Packed chips remained in truck bodies at vertical angles when the rear doors were opened, causing a problem in unloading (See Photo 1). The tire chips were very workable with a five ton dozer (See Photo 2). A freshly placed pile of chips would depress 6 to 12 inches under the first pass of the dozer while being spread. On the second pass they would depress only 3 to 4 inches but then rebound. Even after several passes the material remained spongy but provided good traction for the dozer. The material was spread in lifts of about 18". A lift greater than 18" would not compact satisfactorily. It was also observed that once the depth of chips was greater than 4 feet, the structure became extremely spongy under the weight of the dozer.

Following placement and shaping of the embankment, a geotextile fabric was placed on the slope and covered with approximately two feet of earth borrow. The site was then fine graded, seeded and mulched.

TESTING:

When an area of the embankment reached a height of about 18 feet, a plate load test was conducted. The test loading progressed to a total of 2,028 pounds (471.2 psf) in 200 pound increments. Deflection readings were taken with survey equipment during each load

Unloading became a problem when packed chips would not fall out and had to be pushed with hydraulic rams integral to the truck.

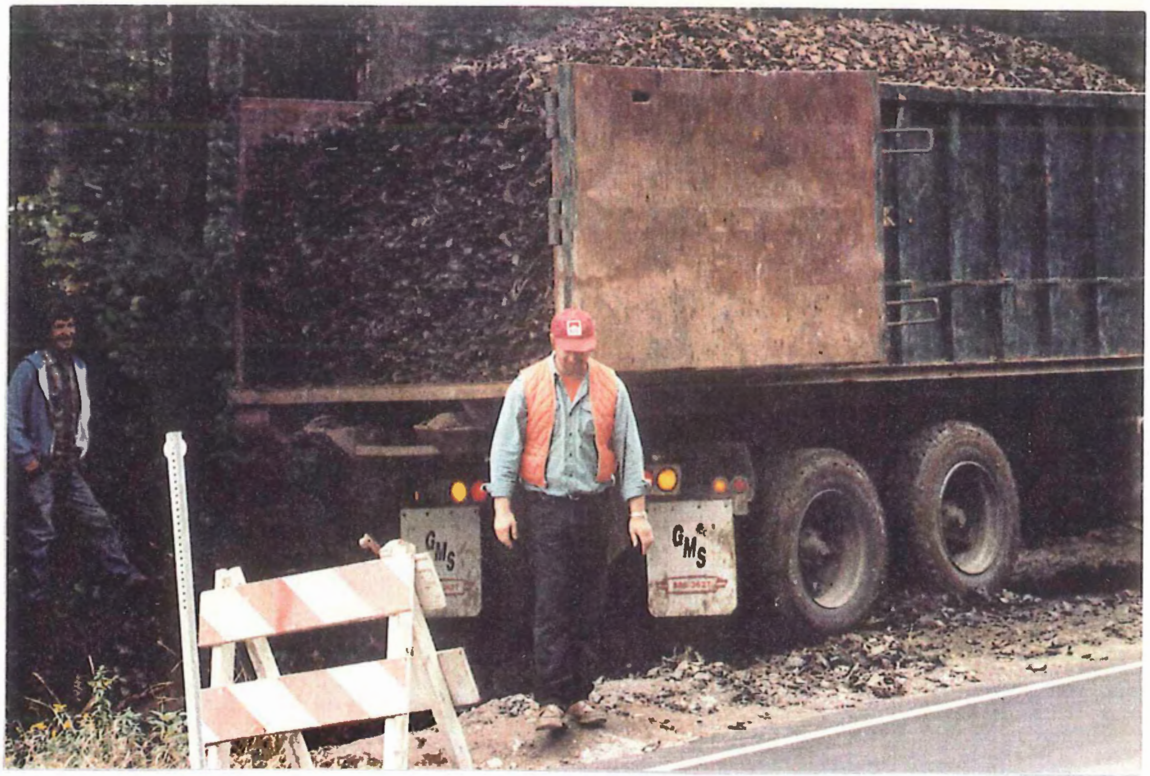


PHOTO 1

Tire chips when the embankment was about twelve feet deep.

PHOTO 2

TESTING: Continued

increment. At 600 pounds, a linear stress vs strain relationship was established with a modulus of 313 psf. A load reduction sequence in 200 pound increments followed from which a non-linear stress-strain curve was developed. A permanent deflection of about .028 inches per foot of fill depth resulted. (See Appendix A)

Unit weight testing using Ottawa Sand was performed resulting in in-situ densities varying from 47 to 56 pcf. Based on the average density of 51 pcf and a laboratory specific gravity of 1.21, an average void ratio of 0.45 was calculated. This corresponds with the typical void ratio of dense Ottawa Sand.

Table 1 MEASURED PHYSICAL PROPERTIES

In-situ density of chips	47 to 56 pcf
Specific Gravity (Laboratory)	1.21
Void ratio (Compacted)	0.45

ENVIRONMENTAL CONCERNS:

One area of concern when considering the use of waste materials is the possibility of harmful leacheate. A report produced by the Minnesota Pollution Control Agency, "Environmental Study of the Use of Shredded Waste Tires For Roadway Sub-Grade Support", published February 19, 1990, described laboratory and field testing of tires. Some new tires and some which had been exposed to the environment for several years were laboratory tested for leacheate contamination under varying conditions of acidity (PH levels between 3.24 and 8.86). These tests found that low levels of various metals would appear in the extraction fluid at low PH levels with the highest concentrations appearing at a PH of 3.5. At the Minnesota sites where tires had been used in road building in wet areas, tests found the water to be more neutral than in the laboratory tests.

Based on concerns addressed in the Minnesota report, samples of flowing water at the culvert inlet and outlet were tested for PH. The PH value at the inlet was 8.8 and at the outlet was 8.3. A soil sample from the stream bed upstream of the culvert was classified as sandy-gravel with a PH value of 7.6. Another sample taken from above and south of the stream (upstream of the road) was a very highly organic sand with a PH value of 7.0. A third sample taken south of the stream (downstream of the road) was highly organic silt with a PH of 7.0.

The results of this testing, while not extensive enough to be definitive, indicate that surface water that may flow through the chips probably will not result in the leaching of metals.

COST:

The total cost of the project was $29,067.00. The cost breakdown is shown in Table 2.

Table 2 COSTS AS CONSTRUCTED

Cost in each category includes labor, equipment and materials.

Site preparation- guardrail removal, signing, clearing	$ 1,045.00
Drainage installation - culvert & stone ditch	6,246.00
Earth borrow (in-place @ $6.23 per cy)	8,086.00
Shoulder construction	603.00
Turf establishment & sign removal	899.00
Tire chips geotextile (in-place @ $4.66 per cy)	12,206.00
Total as constructed	$29,067.00

The portion of the cost allocated to tire chips and geotextile is further broken down in Table 3.

Table 3 COSTS ALLOCATED TO TIRE CHIPS & GEOTEXTILE

Labor	$ 1,682.00
Equipment	
Trucking Vt Tires	3,511.00
Other (Dozer etc.)	2,849.00
Materials	
Typar Geotextile	912.00
Vt. Tire chips (778 cy @ $0.40)	312.00
NH. Tire Chips (1960 cy @ $1.50 inc. trucking)	2,940.00
Total for chips and geotextile (as constructed)	$12,206.00

If the 2738 cy of tire chips had been replaced with earth borrow, at an estimated cost of $6.23 per cy, the total cost of the borrow would have been $17,057.00, which indicates a cost savings of $4,851.00 due to tire chip use.

DISCUSSION:

The chips were purchased in North Ferrisburg, Vt, 55 miles from the project, from a supplier who was unable to maintain a continuous delivery schedule. This caused significant delays in placement. When the Vt. supplier experienced production problems, he arranged for tire chips to be delivered from a source in New Hampshire, resulting in a round trip time of four or more hours. Continuous delivery of the chips would have allowed the project to proceed more rapidly, reducing both labor and dozer rental costs.

The costs incurred on this project are not typical. The price of the chips at the North Ferrisburg plant was significantly less than the usual price due to the supplier's desire to generate a market for the product.

The trucking cost for 778 cy of Vermont chips was $3,511.00 (See Table 3) or $4.51 per cy.

DISCUSSION Continued:

Table 4 below illustrates the estimated costs if all the chips had been from Vermont.

Table 4 ESTIMATED COST WITH ALL CHIPS FROM VT

Labor (no change)	$ 1,682.00
Equipment	
Trucking (2738 @ $4.51 cy)	12,348.00
Other (dozer etc.)	2,849.00
Materials	
Typar geotextile	912.00
Tire chips (2738 @ $0.40 cy)	1,095.00
Total	$18,886.00

Comparing Tables 3 & 4 it can be seen that the cost would have been $6,680.00 higher or $6.90 per cy if all chips had been from VT.

This cost is $0.67 per cy higher than the cost of earth borrow on this job. Thus, cost saving results are inconclusive and seem to depend primarily on the cost of chips delivered to the site.

RECOMMENDATION:

This project utilized tire chips as embankment fill outside any envelope of influence by live load. Until more research has been conducted that might verify properties measured on this project or define other possible, unestablished properties, it is recommended that tire chips not be used as fill material within any area influenced by live load.

FUTURE EVALUATIONS

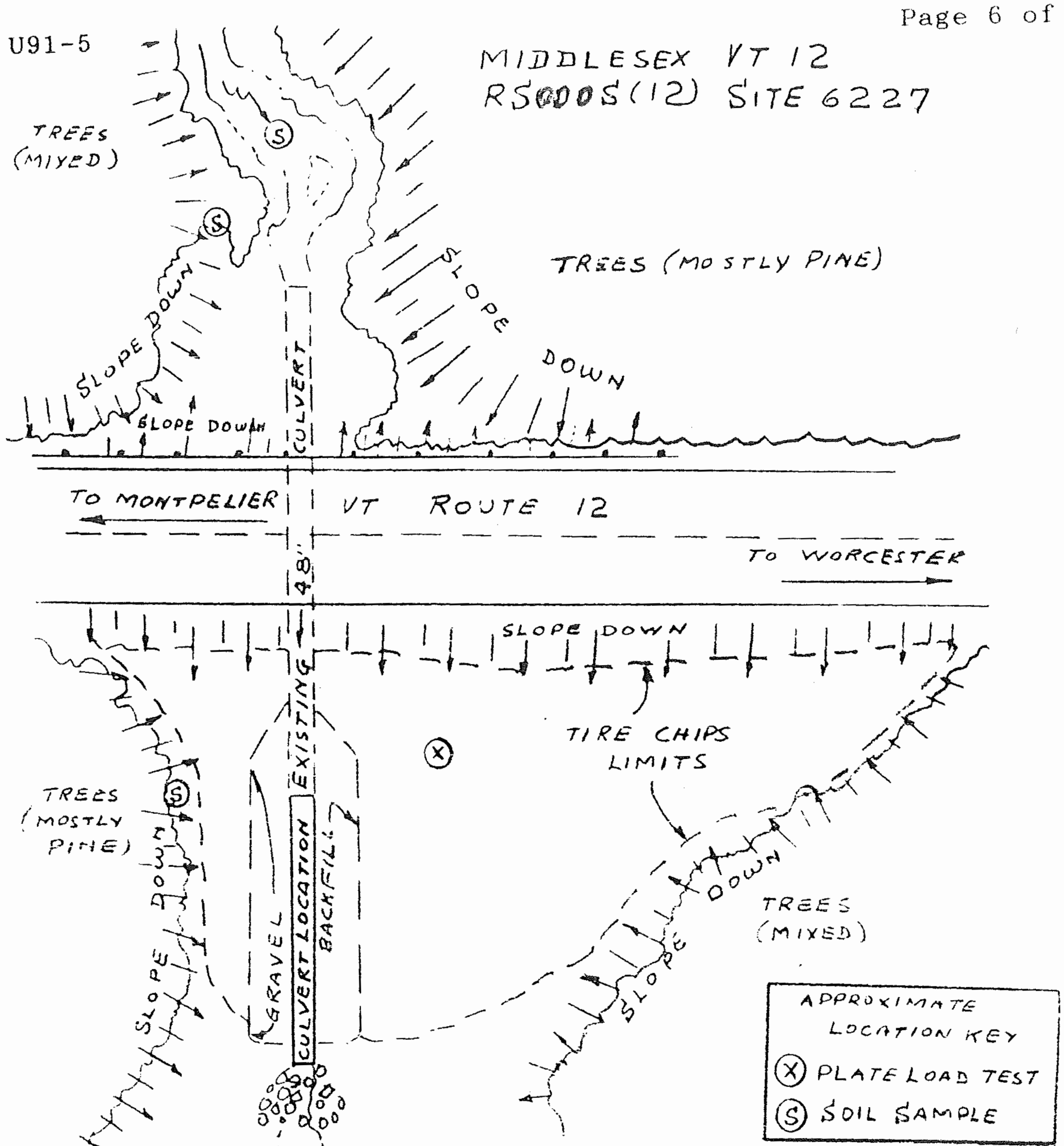
This project will be monitored for at least three years for signs of sloughing of the embankment surface, depressions, wetting of the toe of the slope or cracking of the shoulder or road surface. Soil and water samples will be tested for changes in PH values.

The New England Transportation Consortium currently has a project in partnership with the University of Maine attempting to determine the physical properties and performance of various grades of tire chips. The Consortium project involves extensive laboratory testing and is projected to provide comprehensive data on the performance of tire chips as a fill material.

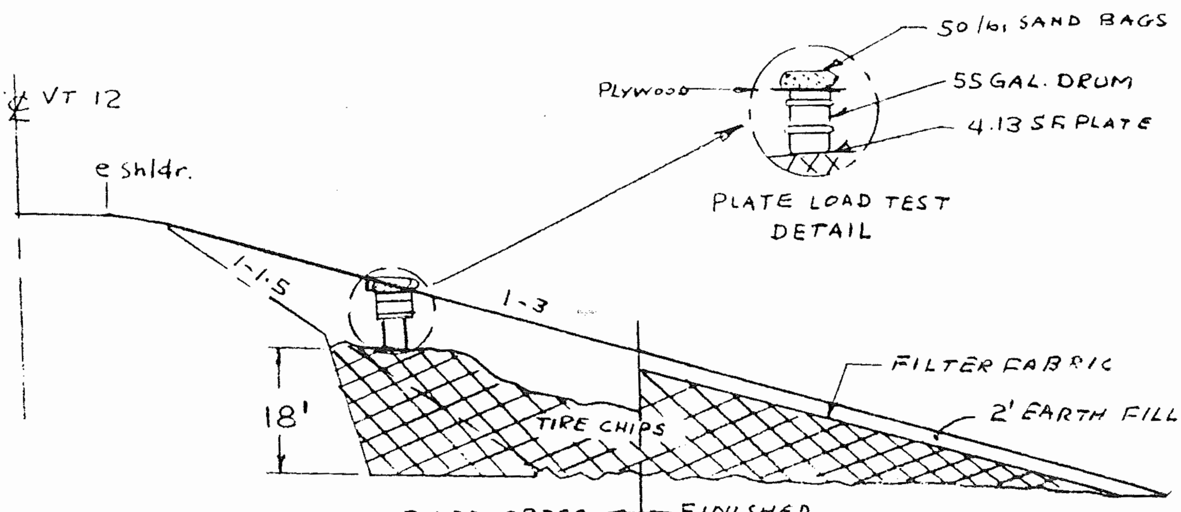
DIST A,B,C,D,E,F,G

Update U91-5

MIDDLESEX VT 12
RS0005(12) SITE 6227



SITE SKETCH
N.T.S.



TYPICAL SECTION
N.T.S.

DRAWN BY BV

APPENDIX A

Plot of Stress-Strain Curves