Tire Chips in the Base Course of a Local Road

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A yearly occurrence in the state of Vermont is affectionately termed the "mud season." Although this phenomenon is often viewed in a joking manner, the condition of the rural gravel roadways in Vermont every spring creates considerable distress and many times hazards for the rural traveling public. This paper presents a discussion of the installation of a layer of tire chips beneath the gravel surface of the roadway. It has been found that the tire chips interrupt ground water capillary action and provide for drainage of water seeping through the roadway surface. The resulting roadway has been found to be substantially firmer and more passable. Even though vehicle loads must be held to a minimum, the overall objective of reducing distress and hazards caused by muddy rural roads appears to have been accomplished.

Pressures are mounting on the transportation community to develop procedures that will accomodate the use of waste scrap tires in highway applications. Mandates include specific requirements for tire rubber use in bituminous mix or asphalt chip seals and stress-absorbing interlayers. The disadvantages of utilizing rubber in asphalt include the high cost of such treatments and the low rubber consumption rates. Other more practical and less costly ways are needed to effectively use up the waste tire stockpiles and the additional tires being added to the waste stream annually.

This paper describes a promising alternative use that can consume a high volume of tires with the potential for cost savings for the user.

Treatment

The alternative use of tire chips as a base-course layer began in 1990 in the town of Georgia, Vermont, with the construction of a 100-m (330-ft) test section on Town Highway (TH) No. 4. The shredded tires were designed to serve as both a drainage layer and a barrier to prevent contamination between a wet silty sand subgrade and the gravel base. The initial success of the treatment, described in Vermont Report U91-06, led to the construction of additional segments in the following 3 years.

Location and Materials

The tire chip base was constructed on TH 4, known as the Oakland Station Road, in the town of Georgia, Vermont. This Class II highway begins where it intersects Route 7 at mm 2.50, 1.6 km (1 mi) north of Exit 18 on Interstate 89 and continues north 5.4 km (3.36 mi) where it terminates at its intersection with TH 1, approximately 0.6 km (0.35 mi) west of Vermont Route 104. The test section starts approximately 2.1 km (1.3 mi) north of the Route 7 intersection and extends north for approximately 760 m (2,500 ft).

The original roadway consisted of approximately 60 cm (2 ft) of gravel on a silty sand subgrade. Gradation tests on samples of the subgrade material revealed from 24 to 43 percent passing the 0.075-mm (No. 200) sieve.

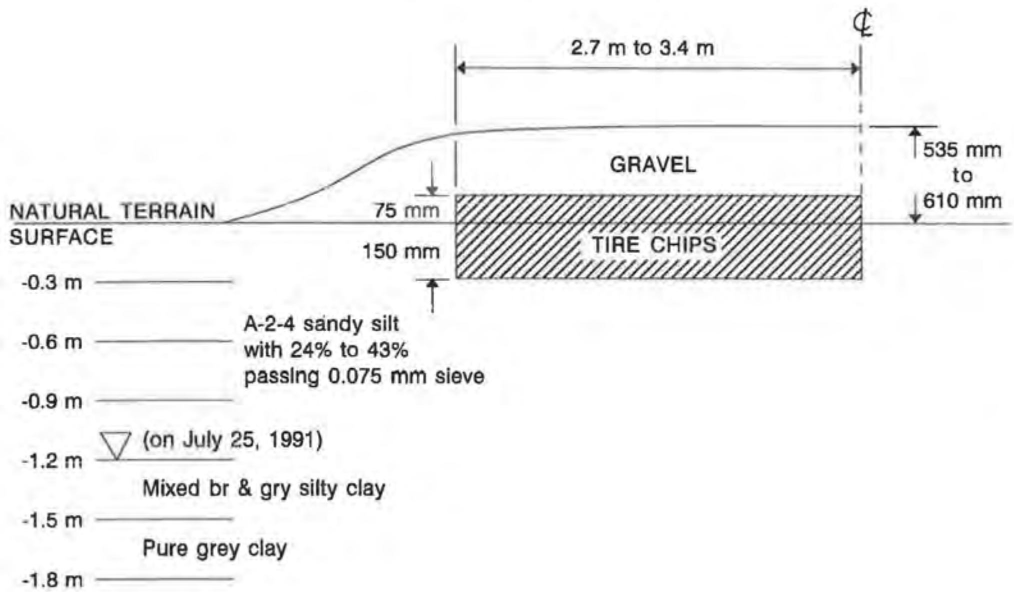

FIGURE 1 Typical section of TH 4, Georgia, Vermont: initial construction.

A high water table commonly resulted in the area's becoming impassable for two-wheel-drive vehicles during the spring "mud season." The pumping action of the traffic had resulted in contamination of the gravel with fine materials. The traffic is in the range of several hundred vehicles per day, with much of it consisting of early-morning and late-afternoon commuters, plus some heavy vehicles such as milk trucks.

Construction Procedure

The construction process included removal of the existing gravel with a backhoe, removal and disposal of approximately 150 mm (6 in.) of silty subgrade material, and backfilling with tire chips. The chips were placed with dump trucks and leveled in a 230- to 305-mm (9- to 12-in.) course with the backhoe. Replacement of most of the original gravel and the addition of several centimeters of new gravel completed the process.

The initial construction in 1990 (Figure 1) included 38 m^3 (50 yd^3) of large tire shreds, of a nominal size of 100 mm × 200 mm (4 in. × 4 in.), which had passed through the chipper once, and 115 m^3 (150 yd^3) of small shreds, of a nominal size of 50 mm × 50 mm (2 in. × 2 in.), which had been chipped two or three times. The chips were transported by town trucks and stock-

FIGURE 2 Dumping tire chips, August 1, 1990.

FIGURE 3 Leveling tire chips with backhoe.

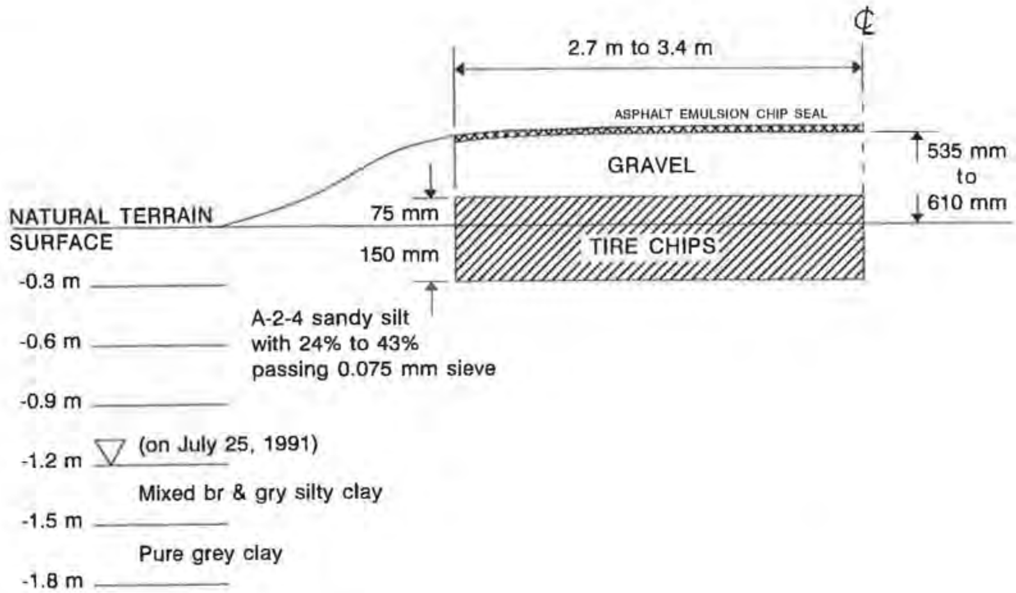

FIGURE 4 Typical section of TH 4, Georgia, Vermont: fall 1992.

piled near the construction site. In subsequent years, only 50-mm (2-in.) chips were utilized and the material was hauled directly from the chipping site in 9.2-m^3 (12-yd^3) dump trucks with sideboards that increased the capacity to 12.2 m^3 (16 yd^3).

In the autumn of 1992, a chip seal (Figure 4) was placed over the initial section of roadway treated in 1990. The process included the placement of a layer of pea stone, a 4.5-L/m^2 (1-gal/yd^2) application of asphalt emulsion, and a mixed 6.4-mm (1/4-in.) and 9.5-mm (3/8-in.) stone surface topping.

Cost Information

The tire chips were purchased from Palmer Shredding, Inc., North Ferrisburg, Vermont, at a cost of \$1.30/m^3 (\$1.00/yd^3). Purchases included 150 m^3 (200 yd^3) in 1990, 220 m^3 (288 yd^3) in 1991, 325 m^3 (426 yd^3) in 1992, and 440 m^3 (576 yd^3) in 1993. Replacement gravel was purchased at a cost of \$5.00/m^3 (\$3.85/yd^3).

Testing and Observations

An inspection of the initial test section on August 30, 1990, revealed the existence of some fine longitudinal cracks in the surface of the gravel roadway. The cracks were noted at eight locations, totaling approximately 19 m (63 ft). A few short transverse cracks were also noted extending off the longer longitudinal cracks. There was no detectable rutting in the wheel path areas.

The test section and adjacent roadway were free of any additional distress when observed on November 20, 1990. At that time, slotted polyvinyl chloride (PVC) well-monitoring pipe 50 mm (2 in.) in diameter was installed at two locations along the easterly toe of the roadway. The water table was found to average 440 mm (17.5 in.) below the ground surface or 290 mm (11.5 in.) below the bottom of the tire chips.

On April 3, 1991 (traditionally, about the start of the mud season), the roadway was inspected, photographs were taken (Figure 5), and the water table ele-

FIGURE 5 Overview of tire chip section, April 3, 1991. Note surface moisture on adjacent untreated sections.

vation was measured. The roadway surface within the test section was visibly dry and free of any rutting. A few fine, longitudinal and transverse cracks were visible on the northerly half of the test section, with most noted in the southbound lane. The water table averaged 305 mm (12 in.) below the natural terrain surface or 151 mm (six in.) below the estimated bottom of the tire chips. The water table elevation was 140 mm (5.5 in.) higher than that recorded the previous November.

By comparison, the untreated roadway portions north and south of the tire chip section were in poor condition. The surfaces were visibly wet and revealed numerous ruts, cracks, and boils. The poor areas were soft to walk on and water could be drawn to the surface with a tamping action. It must be noted, however, that in general, TH 4 was in better overall shape than in other years, because of a milder winter with below-average snowfall and a dry spring season.

On July 25, 1991, construction of another segment was observed and photographs were taken (Figures 6–9). At that time, the backhoe was utilized to place two additional monitoring pipes and to dig a test pit in the year-old tire chip section. The soil at the well sites began as a sandy silt that approached saturation approximately 120 cm (4 ft) below the road surface elevation, changed to a mixed brown and grey silty clay at a depth of 150 cm (5 ft), and became a pure grey clay at a depth of 180 cm (6 ft) (Figures 1 and 2).

The 60-cm × 180-cm (2-ft × 6-ft) test pit was dug in the left wheelpath of the southbound lane, 7.6 m (25 ft) north of the southerly well point placed in 1990 (Figures 10 and 11). The pit revealed 530 mm (21 in.) of gravel over 200 to 230 mm (8 to 9 in.) of tightly compacted tire chips. The top 150 mm (6 in.) of gravel contained 8 percent minus 0.075 mm (No. 200) sieve material, whereas the remainder averaged 15 percent minus 0.075 mm material. The top side of the chips

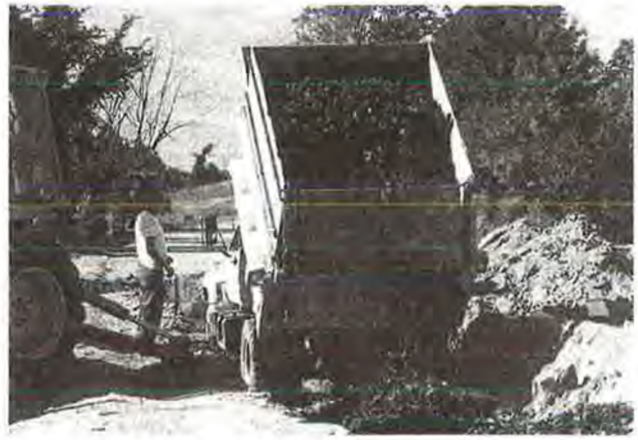

FIGURE 7 Backfilling excavation with 16-yd^3 load of tire chips.

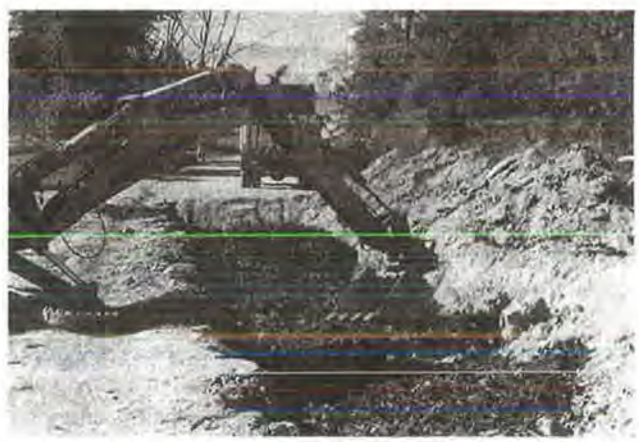

FIGURE 8 Leveling tire chips with backhoe to obtain ±8-in. layer.

FIGURE 6 Roadway excavation included stockpiling of ±22 in. of existing gravel and disposal of 8 to 12 in. of silty sand subgrade.

FIGURE 9 Backfilling trench with original gravel.

FIGURE 10 Excavating test pit in 1990 construction project.

showed a trace of moisture whereas the bottom side was dry. The silty sand beneath the chips contained enough moisture for it to hold together when squeezed (Figure 12). No attempt was made to locate the water table elevation.

Falling weight deflectometer (FWD) tests were taken on the 2-month-old chip seal surface in November 1992. The test values indicated a significant deflection of the test surface, which would suggest that the tire chip layer allows too much deflection under heavy loads for any future bituminous pavement to survive without additional gravel cover over the tire chip layer.

On August 12, 1993, construction of another tire chip base segment was observed and the 11-month old chip seal was inspected. A nearly full-width transverse crack and a few random longitudinal cracks were visible in the northbound lane. A nearly continuous longitudinal crack extended for one-half the length of the treatment in the southbound lane. All of the cracks were very fine, and stone loss was minimal. Several bituminous patches had been placed along the centerline where there had been some loss of the seal at the construction joint.

On October 31, 1994, FWD readings were taken at four locations, two on gravel sections without tire chips (Test Sites 1 and 2) that now have a 75-mm (3-in.) bituminous concrete surface and two on the sections with tire chips (Test Sites 3 and 4) that now have a chip seal. Deflections and structural numbers were as follows:

Test Site	*Deflection (mm)*	*Structural No.*
1	0.73	2.80
2	0.87	2.52
3	2.60	1.61
4	3.27	1.49

These data should be considered primarily in a qualitative manner when the test sections are compared. Calibration of the FWD is valid only up to deflections of 2 mm (80 mils). The measurements confirm that vehicle loads on the tire chip sections must be confined to the traditional (existing) automobile traffic with an occasional milk truck.

Summary and Conclusions

The construction of a test section of highway with a tire chip base in the town of Georgia, Vermont, and its performance to date can be summarized as follows:

- Approximately 65,000 tires chipped to a 50-mm (2-in.) size were placed on 760 m (2,500 ft) of TH 4 in Georgia, Vermont.

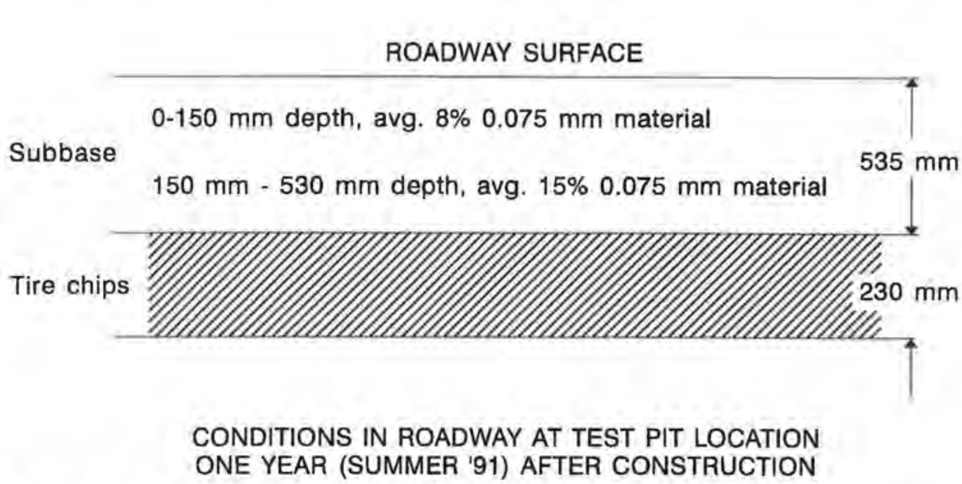

FIGURE 11 Conditions on roadway at test pit location one year after construction (summer 1991).

FIGURE 12 Base consisted of 20 to 22 in. of dirty gravel over ±8 in. of compacted tire chips; gravel was dry, whereas silty sand subgrade contained enough moisture to hold together when squeezed.

- The tire chips provided a tightly compacted layer averaging 230 mm (9 in.) thick beneath 530 mm (21 in.) of poor-quality gravel that contained an average of 15 percent minus .075 mm (No. 200) sieve material.
- The tire chip layer enhanced the poor-quality gravel by cutting off the capillary rise of subsurface water and by reducing the moisture content of the gravel through good drainage.
- The muddy road conditions prevalent in past spring seasons did not recur following the placement of the tire chip layer.
- The use of tire chips at a cost of $1.30/m^3 ($1.00/yd^2) reduced the need for additional gravel that would cost $5.00/m^3 ($3.85/yd^3).
- An asphalt emulsion chip seal placed on the initial test section revealed only minor distress through its first year of service.
- FWD test values suggest the tire chip layer will allow too much deflection under heavy wheel loads for a bituminous pavement to resist cracking, unless an additional layer of gravel is placed over the tire chips.

Recommendations

The Agency of Transportation should encourage cities and towns to utilize tire chip layers in town highway bases, with an emphasis placed on areas where moisture conditions are a problem and future paving is unlikely. If the cost of hauling tire chips makes some potential locations unsuitable, consideration should be given to the concept of collecting tires at regional solid waste sites and shredding them with portable equipment.

Additional deflection testing is warranted, with emphasis placed on the comparison of values for similar gravel segments with and without the tire chip layer.

Followup

Monitoring will continue on the tire chip base and additional reports will be prepared when significant information is obtained.