Wood Chips as a Lightweight Fill
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**WOODCHIPS AS A LIGHTWEIGHT FILL**

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Long-term durability of the wood chips was a significant concern regarding their use as a fill material for roadway embankments. Nineteen years after the placement of the wood chips for the T.H. No. 53 project, no settlement problems have been reported. The maintenance history of the roadway where the wood chips were used in the embankment was not any different than the rest of the project. The fact that the roadway embankment did not show any noticeable settlement over 19 years indicates that the chips are capable of providing long term support.

Based on the performance of the widenings, Mn/DOT decided to sample the chips at several locations to determine their condition. Two test sections, the wood chip working platform and the wood chip embankment, were selected for sampling.
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Final Report

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Wood Chips as a Lightweight Fill

Summary

Wood products have been used as a lightweight fill in roadway embankments in the past, primarily in situations where slope stability was a concern. The U.S. Forest Service reported [1] on the use of sawdust and bark chips as a lightweight fill in slide areas. That report indicated that sawdust was commonly used as a lightweight fill, or to provide support over soft soils near sawmills in the United States, Canada, and Norway. No information, however, is available regarding the use of wood chips as a lightweight fill for embankments floated over peat swamps. The Minnesota Department of Transportation (Mn/DOT) conducted an experiment with such a construction technique in 1976 on T.H. No. 53 in Koochiching County.[2,3] The trees used for manufacture of the chips were primarily aspen with the common name of poplar.

Long-term durability of the wood chips was a significant concern regarding their use as a fill material for roadway embankments. Nineteen years after the placement of the wood chips for the T.H. No. 53 project, no settlement problems have been reported. The maintenance history of the roadway where the wood chips were used in the embankment was not any different than the rest of the project. The fact that the roadway embankment did not show any noticeable settlement over 19 years indicates that the chips are capable of providing long term support.

Based on the performance of the widenings, Mn/DOT decided to sample the chips at several locations to determine their condition. Two test sections, the wood chip working platform and the wood chip embankment, were selected for sampling. The samples were than placed in plastic containers for transport and delivery to Dr. Elmer Schmidt at the University of Minnesota. Dr Schmidt initially evaluated the chips on October 3, 1995 for visual evidence of degradation.[4,5] Laboratory tests were conducted within the following week.

The chips looked remarkably good when sampled as shown by the photographs in Figure 3. It would have been very difficult to distinguish the 19-year-old chips from new chips. The evaluation by Dr. Schmidt found that all the chips sampled occupied about the same volume as new chips; however, the chips at the bottom of the fill (near the peat) had less mass. There was some degradation of the wood fibers and cell walls, possibly due to bacterial activity.
It can be concluded that the wood chips placed in 1976 are providing excellent long term performance as a lightweight fill material. It can also be concluded that the use of wood chips may be an economic engineering alternative to consider for building embankments over peat swamps.
Background

In 1976, wood chips were used as a lightweight fill by the Minnesota Department of Transportation (Mn/DOT) on a research project located in Koochiching County on Trunk Highway No. 53 between International Falls and Ray (about 30 km southeast of International Falls). This was a rehabilitation project that included shoulder construction on each side of the existing roadway followed by an asphalt overlay. The embankment width prior to rehabilitation was about 9 m (30 ft). A 13.7 m (45-foot) top was required to accommodate two 3.66 m (12-foot) driving lanes and 3.05 m (10-foot) shoulders.

The construction included grading work to allow for the 3.05 m (10-foot) shoulders on each side of a 24-foot wide two-lane roadway. The existing roadway embankment crossed three swamps. The original embankment was floated across the peat in all three swamps. Soil borings indicated the peat ranged from 2.4 to 4.6 m (8 to 15 ft) deep.

At the time, the common widening practice for roads floated over peat was called "keying." Keying involved excavation of the peat on each side of the existing embankment and backfilling with a granular material. Keying required closing the road to all traffic during construction. T.H. 53 was a main transportation link and was vitally important to the economy of International Falls. It was the only road available between the "Falls" and communities to the southeast without a lengthy detour. Between Ericsburg and Ray, the roadway centerline is 27.4 m (90 feet) southwest of the railroad that served the Falls from the southeast. The railroad embankment was also floating on the peat as it crossed the two swamps between Ericsburg and Ray. Therefore Keying presented a significant risk that a slope failure could develop in the railroad embankment during the construction. This is the only rail link from International Falls to other locations in the United States. The only other rail access to International Falls and its substantial wood products industry, is through Canada.

Because of the risks, keying was an unacceptable alternative. The other alternative was to acquire a new right-of-way away from the railroad and construct a new roadway across the swamps, or to "float" the widening over the existing peat. Although there was a long history of "floating" embankments over peat in Minnesota, it was not a standard construction procedure for the Department, nor was there any information available regarding "floating" widenings.

Floating presented several design problems that needed to be addressed.

- Placement of any widening fill over the peat would cause settlement, and possible slope failures within the existing embankment.
• The settlement of the widening would cause some additional settlement in the existing embankment.

• Lateral displacement of the peat, if it would occur, was expected to be away from the existing embankment.

Minimizing the weight of the fill was expected to reduce the amount of settlement movement. At that time, however, there was limited information available regarding construction techniques with lightweight fills or geofabrics. The local availability of wood chips led to the design approach of utilizing wood chips as a leveling material and as a mat or "working platform" for constructing the widenings for all of the swamp areas. One section utilized the wood chips for 0.6 to 1.5 m (2 to 5 ft) of fill material that was capped by 0.6 m (2 ft) of clay and 460 mm (18 inches) of Class 3 (natural sand and gravel) subbase material.

Performance of Wood Chips

The wood chips have now been in place for 19 years in Koochiching County on Trunk Highway No. 53. The widening across the swamps has performed well with no notable settlement since the initial settlements associated with the construction. Questions remain, however, about how long the chips will last before they start to decompose. The site was visited on September 25 and September 26, 1995, to remove samples of the wood chips from two sections constructed in the swamp near Reference Post 151. The sections sampled were the wood chip working platform and the wood chip embankment section. Figures 1 and 2 show typical cross sections of the sections sampled and the approximate sampling locations. A backhoe was brought to the site by the Mn/DOT maintenance staff at International Falls to dig down into the widenings. Mn/DOT research staff and Erland O. Lukanen, the Research Project Engineer for the project, were on site to observe the condition of the widening, and to sample the wood chips for evidence of decay or other forms of deterioration.

The condition of the widening sections all appeared to be excellent with no signs of slope instability or visually notable differential settlement. A backhoe was used to dig down into the embankment. The excavations were about 8 m north of the centerline of the highway. The wood chips at all the sampling locations visually appeared to be the same as when they were placed as shown in Figure 3. The chips were in a very moist to saturated condition; had clear, bright colors similar to freshly chipped wood; and felt sound to the touch. There was no unusual odors noted during excavation. Samples were placed in plastic concrete cylinder molds, marked, and covered for transport to the University of Minnesota for evaluation by Dr. Elmer L. Schmidt. The chips were initially inspected by Dr. Schmidt
on October 3, 1995, one week after the samples were obtained. In that time, the chips had darkened considerably to a very dark brown, possibly due to a tannate oxidative stain [5].

Dr. Schmidt produced two evaluation reports: The first describes the evaluation processes and the laboratory tests results [4]. The second report discusses the evaluation results [5]. The evaluation concluded that the chips were occupying approximately the same volume at the time of sampling as they did when placed. His evaluation revealed, however, that deterioration is taking place, particularly in the samples taken near the peat. Observations under microscope revealed damaged wood fiber and fiber cell walls. Degradation of this nature is consistent with bacterial action.

**Predictions of Chip Degradation**

The chips have been in place with no significant volumetric loss in the 19 years since they were placed. This would infer that the use of wood chips as a lightweight fill in similar environments is a viable alternative that may be considered for future projects. The condition of the chips provide reasonable confidence in predicting at least 35 years of service from the chips. At this time, however, there is no information available to allow an estimate to be made of how long the chips will actually stay in place.

**Settlement**

Over time, deterioration of the wood chip fill will result in settlement of the widening, resulting in the need to shim the surface to restore elevation and cross-slope.

There are a number of road embankments in Minnesota that are floating over peat swamps. Many of these embankments were constructed with narrow width and steep ditch slopes. Upgrading these roads to current geometric standards requires that the embankment be widened. Widening of embankments presents a unique geotechnical challenge. The existing embankment generally has been in place for a sufficient length of time so that the rate of settlement is very low. Two alternatives available for widenings in these situations include:

- Excavation of the peat. The excavation could either be attempted along the sides of the existing embankments (keying), or total excavation of the existing embankment. The excavation is typically filled with a granular material.
Floating the material for the widening. A variety of geotechnical materials and techniques are available for floating an embankment including geotextiles and lightweight fills.

Excavation requires that the road be closed to all traffic during construction and requires significant costs for excavation and backfill materials. In addition, there are significant problems and costs associated with disposal of the excavated peat and with the availability and delivery of the granular backfill material. Floating a widening fill over the peat will settle over time, and may also result in slope failures. Generally, floating the embankment represents some risk of settlement or slope failures, will require future maintenance, and will provide poorer serviceability performance; these drawbacks, however, may be acceptable considering the cost and inconvenience of the excavation alternative. Recent geotechnical alternatives, such as stone columns used in conjunction with lightweight fills, may improve the performance of widenings.

The construction cost of excavation and backfill is generally much higher than the cost for floating widenings. Adding in user-delay costs, and the potential risk costs in the case of the T.H. 53 project, make widening a much more reasonable alternative. Once the decision has been made to use a floating section, a widening design must be developed. The design process includes obtaining a geotechnical evaluation to predict the amount of settlement and possibility of slope failures. Based on the settlement and stability predictions, the allowable weight of the fill can be determined. If the height of the required embankment will result in too much weight, lightweight fills may be considered. In Minnesota, wood chips and shredded tires have been used as lightweight fills. Wood chips are expected to eventually break down due to rotting and shredded tires cannot be placed below water due to environmental concerns.

Many of the peat swamps are in forest regions where there are adequate resources for constructing an embankment with wood chips. Concerns about the long-term effectiveness of wood chips as a lightweight fill may prevent their use. The evaluation of the condition of the T.H. 53 wood chip embankment project constructed 19 years ago demonstrates the longevity or potential longevity of wood chips in an embankment.

The investigation shows that there was no significant loss of wood chip volume over the past 19 years. The study has shown, however, that there has been some degradation of the chips, particularly at the peat interface. At this time, it is not possible to state how many more years the chips will retain their original volume; however, the information indicates that the degradation of the volume of the chips will be slow. At some point in the future, there may be sufficient settlement to require a surface correction for elevation and cross-slope.
Maintenance that will eventually be required to sustain grade and cross-slope as the chips disintegrate will result in an increase in the embankment weight over the peat. Care must be taken to make sure additional materials will not generate excessive settlement. Any additional materials placed to maintain grade should be carefully recorded, and a geotechnical evaluation should be made before any significant increase in fill weight.

**Cost Considerations**

There are two significant components to a cost-based selection:

- First (Construction) Costs, and
- Maintenance costs.

Excavation and backfill is high in first costs and less in future maintenance costs, whereas floating tends to be lower in first costs and possibly have higher maintenance costs. This was illustrated in Appendix A - Cost Analysis of Lukanen's Initial Report [2]. The first cost of all of the floating sections was about one fourth of the engineer's estimate cost of excavation and backfill using the "Keying" method. No consideration was given in that analysis for the cost of user delays or the cost of the potential risk of slide failure of the railroad embankment. The cost associated with a slide failure of the railroad embankment was not estimated but was considered to be much higher than the construction costs for the highway.

Unit wet weight of typical chips is about one fourth that of mineral soil. Therefore, the amount of settlement during a widening of existing floating roadway can be reduced by replacing a part of the mineral fill with a lightweight fill made up of wood chips.
References


Figure 1. Wood chip working platform (Test Section 4).

Figure 2. Wood chip embankment (Test Section 5).