Advantage

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Contents

Reducing aggregate thickness on gravel roads designed for log trucks equipped with TPCS

Abstract

FERIC conducted a field study to determine the optimum aggregate thickness for roads traveled primarily by trucks equipped with tire pressure control systems (TPCS). The main objective was to establish if savings during road construction could help justify the cost of TPCS technology. The initial results showed that aggregate thickness could potentially be reduced by more than 28% at the test location. This reduction would result in savings in aggregate costs of at least $4000/km, which could help cover the cost of TPCS.

Keywords:

Tire pressure control system, TPCS, Central tire inflation system, CTI, Forest road design, Aggregate thickness, Unpaved roads.

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Introduction

Tire pressure control systems (TPCS), also known as central tire inflation (CTI) systems, are used extensively by forestry companies in Canada to optimize tire pressures to match the working conditions. The industry is implementing TPCS technology to improve access to difficult sites and extend the haul season. However, the cost of TPCS is often seen as an expense rather than as an investment, thus discouraging its introduction. Although many road maintenance and truck-related cost savings have been observed (e.g., less tire wear and damage, cycle time improvements, etc.), these benefits can be difficult to quantify and may not cover the full cost of TPCS. If additional savings could be generated during road construction, this would help bring about a wider introduction of TPCS to the forestry sector.

Reducing tire pressures has been found to improve ride comfort, traction and mobility, slow the development of deep ruts, reduce aggregate losses and sediment production, prevent washboard formation, reduce grading requirements and extend the haul season. Earlier work conducted by FERIC (Bradley 1996) has shown that rut depth on unsurfaced subgrades can be reduced by 77% when traveling at low tire pressures. A study conducted in the U.S. by Weyerhaeuser Company Limited (Keller et al. 1993) reported that roads constructed with 25 to 50% less aggregate than normal performed adequately when subjected to traffic by TPCS-equipped vehicles only. These operations subsequently adjusted their road designs to specify 25% less aggregate for roads constructed with crushed aggregate that would be used exclusively by TPCS-equipped trucks.

The main objective of this study was to evaluate if comparable aggregate reductions can be implemented under Canadian forest road conditions and to measure the cost-effectiveness of using TPCS. The study was conducted in cooperation with Weyerhaeuser Company Limited (Dryden, ON division) during the summer of 2004.

Study layout and methodology

A 1.1 km-long test road was built on a subgrade comprised primarily of fine-grained soils ranging from silty clays to high-plasticity clays. The subgrade was compacted shortly after construction by a padfoot compactor and the road was then divided into four test road sections. The sections were surfaced with unscreened natural pit-run materials to a thickness of either 90, 100, 140 or 180 mm. These thicknesses ranged from 28 to 64% less than the current design standard of 250 mm used by Weyerhaeuser (ON). The aggregate was classified as well-graded sand (SW) and considered poor quality for surfacing applications. To provide better performance, this material would require higher fines content and fewer cobbles (Légère and Mercier 2003).

The strength of the subgrade (after compaction) and the aggregate layers were measured by FERIC using a Clegg Hammer. The results were then correlated to California Bearing Ratio (CBR) values. The strength of the compacted subgrade was equivalent to an average CBR of 10 over the 4 sections. For the aggregate layers, the two thinnest layers showed the lowest strength (average CBR of 10 and 15) whereas the two sections with thicker layers yielded higher values (CBR of 17 and 20).

During testing, the road was trafficked by a fully loaded eight-axle truck (two axles were lifted but would normally be used on highways) equipped with a TIREBOSS™ TPCS, manufactured by TPC International Ltd. (Figure 1). A cold tire inflation pressure of 55 psi was used for both the trailer and drive-axle tires during travel, whereas the steer axle tires were kept at a regular highway pressure of 100 psi. A total of 54 passes were made by the same truck over the course of three days during which rut depth growth, as well as other surface distress problems, were measured (Figure 2). Note that Weyerhaeuser (ON) considers that a rut depth of less than 75 mm (3 in.) is acceptable for this class of road (i.e., tertiary road).

Figure 1. A fully loaded truck equipped with a TIREBOSS™ TPCS was used during the study.

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Summary of results

The thinnest-surfaced section, which had 90 mm of aggregate (64% reduction), rutted significantly after only 5 passes and required maintenance work by a grader and excavator to restore the surface. After an additional 20 passes, parts of this section failed once again, at which point 12 loads of aggregate were added. Nonetheless, average rutting remained high (>90 mm) even after the repairs, with some localized failures exceeding 200 mm, in part because of a high moisture content in the subgrade caused by very poor drainage.

The three other sections (28, 44 and 60% reduction) performed well throughout the test, with no major rutting (average from 40 to 65 mm) after 54 passes, partly because of the thicker aggregate layers, but also because of better drainage which was found to directly impact subgrade and aggregate layer strength.

On all four sections, and especially on those with the thicker layers, it was obvious at 54 passes that the surface material was starting to push to the sides of the road, mainly because of its poor gradation and lack of cohesion. The displacement of material created large berms, as high as 200 mm at some locations, thus obstructing drainage of the road surface. The larger these berms grew, the less surface material remained available to protect the subgrade from rutting. During normal operations, this material would be restored by routine grading before reaching this level.

Based on these results, and given that road performance can be quite site specific, we recommend that those wishing to implement this approach under similar conditions target a cautious initial aggregate thickness reduction of 25-30%, until the findings can be substantiated on a longer test road and under a wider range of subgrade conditions (i.e., soil type, drainage, moisture conditions, strength). FERIC plans to conduct further testing during the summer of 2005 to validate if a 25-30% target aggregate thickness reduction can perform at higher traffic levels, and to assess the effect of routine maintenance (grading) on the development of ruts and berms.

A cost analysis revealed that at an in-place aggregate cost of $10.25/m³, a 25-30% reduction would generate a savings in construction cost of approximately $4000/km at the test location. Road maintenance costs still need to be documented and compared to those of a standard design approach, but if they are equivalent, building only 6 km of road with this design would cover the cost of one TPCS.

Implementation

For effective implementation of reduced aggregate thickness, FERIC recommends that road builders should:

- Characterize subgrade and aggregate materials and define the wettest subgrade conditions during the road-use period;
- Target an aggregate thickness reduction of 25-30% from the standard thickness as a starting point for testing on your operations (Note that this design approach is a rule-of-thumb and can be site specific);
- Compact the subgrade soils at optimum moisture content to achieve maximum density. Compaction may not be required if the material has settled for a season prior to adding aggregate;
- Provide appropriate roadside drainage, cross-drainage, and crowning;

Figure 2. FERIC monitored the growth of rutting in each wheel track during vehicle travel.

This report summarizes the findings presented in an internal FERIC report entitled *Reducing aggregate thickness on forest roads designed for log trucks equipped with TPCS* by Légère and Mercier (2004), available to FERIC members on the FERIC Web site.

- Additional thickness or the standard aggregate thickness should be maintained on and before hills;
- Enforce a TPCS road policy and control system (i.e., only trucks operating with reduced tire pressure are allowed on these roads);
- Work with your TPCS and tire supplier to define suitable settings for tire pressure based on tire size, axle loads, and travel speeds;
- Have trucks vary wheel paths and travel on top of the raised edges of ruts to help heal and compact the surface. The road surface must be wide enough (min. of 5.5 to 6 m) to practice this technique;
- Establish a partnership between company and contractor to share the initial purchase price of TPCS since both the truck owner and the forestry company would benefit from these systems (i.e., both road and trucking);
- Document the long-term performance of the road, and adjust the target aggregate thickness reduction based on road performance;

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