Caulk Boot versus Non-Caulk Hiking Boot: A Test of Traction on Forest Ground Surfaces

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INTRODUCTION

There is uncertainty regarding the effectiveness of using caulk boots vs. non-caulk hiking boots in silviculture work in the interior of British Columbia.[1] WorkSafeBC regulation 8.23, states "caulked or other equally effective footwear must be worn by workers who are required to walk on logs, poles, pilings or other round timbers", but does not specifically require caulk boots to be worn on steep slopes. Caulk boots are used almost exclusively by silviculture workers in coastal B.C. but are not commonly used in interior B.C. even though there are many situations where they may provide superior traction. Instead, workers in interior B.C. have a preference for non-caulk hiking boots. Workers will often select their boots based on personal preference rather than on information about the boot's traction performance. Additional information regarding the differences in the traction of caulk boots and non-caulk hiking boots on various forest ground surfaces would help most workers make better-informed choices. Understanding the differences in traction is one of the most important factors when selecting a work boot in any situation and is especially true in the hazardous ground conditions of forest workers. For this reason, FPInnovations constructed a testing apparatus designed to measure and compare the static coefficient of friction of caulk boots and non-caulk hiking boots on four common types of ground cover surfaces in B.C. forests.

OBJECTIVES

The objectives of this test were to perform the following:

- Measure the difference in traction between caulk boots and non-caulk hiking boots on four ground cover surfaces; both wet and dry

- Produce a quantitative measure of how the level of caulk and tread wear affects traction.

METHODS

FPInnovations built an apparatus that applied vertical weight to a boot resting on a sample of ground surface that was mounted on a horizontal sliding floor (Figure 1). The apparatus used four lead plates to apply a vertical weight of 55 kg to the boot tread. Vertical weight was measured with a scale where the boot tread made contact with the ground surface. The same weight was used for each test measurement.

Tension was then applied to pull the sliding floor a short distance (e.g., 1–2 cm) forward while the boot remained stationary (Figure 2). The movement of the white mark in the picture indicates the short horizontal movement of the sliding floor. A load cell (Figure 3) was used to measure the tension required to initiate movement of the floor with the attached surface cover, and a CR23X Micrologger® datalogger (Figure 4) was used to read the horizontal tension in millivolts which was converted to kilograms.

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[1] John Betts, Western Silviculture Contractors' Association, personal communication, Nov. 11, 2014.

The downward vertical weight on the boot (F_N) and the tension required to initiate a horizontal movement (F_S) of the sliding table under the stationary boot were used to calculate a static coefficient of friction ($\mu_S = F_S/F_N$) for each boot on the different ground surfaces (Appendix). The coefficient of friction (COF) is a measure that describes the “grippiness” of two surfaces that are sliding against each other. A slippery surface will produce a lower COF compared to a sticky surface. The COF will be different for each pair of materials (i.e., boot tread and surface). For example, if a boot has good traction on a particular surface, it will have a higher COF than the same boot experiencing a lower traction on a slippery surface. Similarly, a boot that has good traction will have a higher COF on a particular surface than a different boot that has bad traction on the same surface.

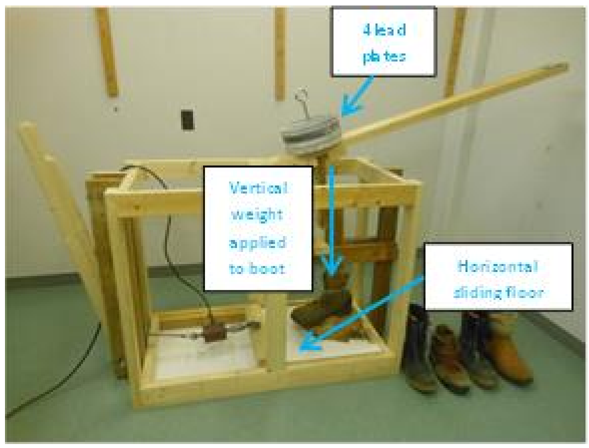

Figure 1. Boot traction testing apparatus

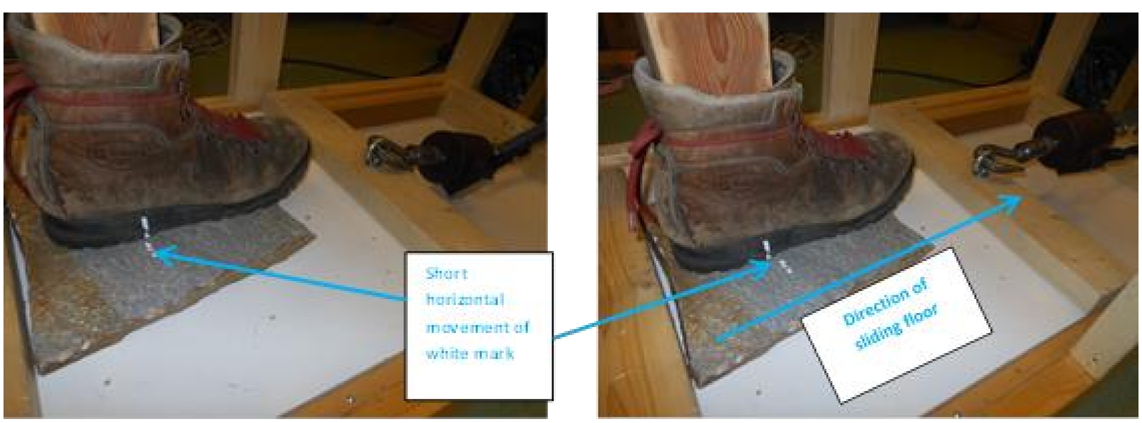

Figure 2. Horizontal movement of the sliding floor under a stationary hiking boot

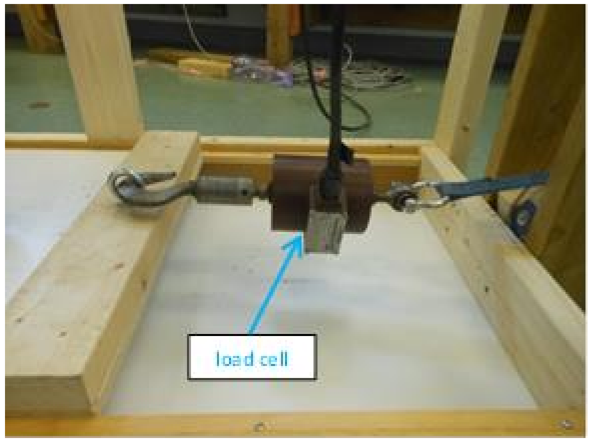

Figure 3. Load cell measuring horizontal tension

Figure 4. CR23X Micrologger® datalogger

Measurements were taken for five boots—two non-caulk hiking boots (Figure 5) and three caulk boots (Figure 6):

- non-caulk hiking boot with a worn Vibram tread, estimated to have approximately 40% of the tread remaining
- non-caulk hiking boot with a new Vibram tread
- caulk boot with worn steel caulks, estimated to have approximately 40% of the caulks remaining
- caulk boot with new steel caulks
- caulk boot with ceramic caulks which remained at a consistent level of wear, estimated to be similar to having 80% of the wear level of steel caulk treads

Figure 5. Non-caulk hiking boots showing worn Vibram tread with approximately 40% of the tread remaining (left), and new Vibram tread (right).

Figure 6. Boots with worn steel caulks (left), new steel caulks (centre), and ceramic caulks (right).

Measurements were taken on four different surfaces (Figure 7):

- log with bark
- log with no bark
- rock
- simulated forest duff layer

It was assumed that the tight root mat and slightly compressed soil matrix on the underside of a commercial sod layer would provide a surface similar to a duff layer with exposed soil on a forest floor. Therefore, carpet tacking was used to secure the sod, grass-side down, to the sliding floor (Figure 7). The four surfaces were tested under both wet and dry conditions. Twenty measurements were recorded for each boot/surface combination. Traction on actual harvesting slash could not be measured because simulating realistic conditions with different combinations of small- and large-diameter pieces was beyond the capability of the testing procedures. Nevertheless, traction on a log surface was measured and some assumptions could be made about traction on large-diameter, non-mobile slash.

Figure 7. Four different surface types were used in the test (from left to right): log with bark, log with no bark, rock, and simulated forest duff layer.

RESULTS AND DISCUSSION

The boot traction test results are presented in Figure 8. The new Vibram tread had better traction than the worn Vibram tread in every test. Ceramic and new steel caulk treads had better traction than Vibram treads in all the log surface tests. However, worn caulk treads had lower traction than Vibram treads in many of the tests. New Vibram treads had slightly higher traction than caulk treads on the rock surface tests. The ceramic and new caulk treads had better traction than the Vibram treads on the duff layers on both dry and wet duff layer tests. The wet commercial sod was allowed to dry indoors for 24 hours for the dry test so the “dry duff layer” still contained enough moisture to remain relatively pliable. Results may have varied if the sod was allowed to dry to a hard compact surface.

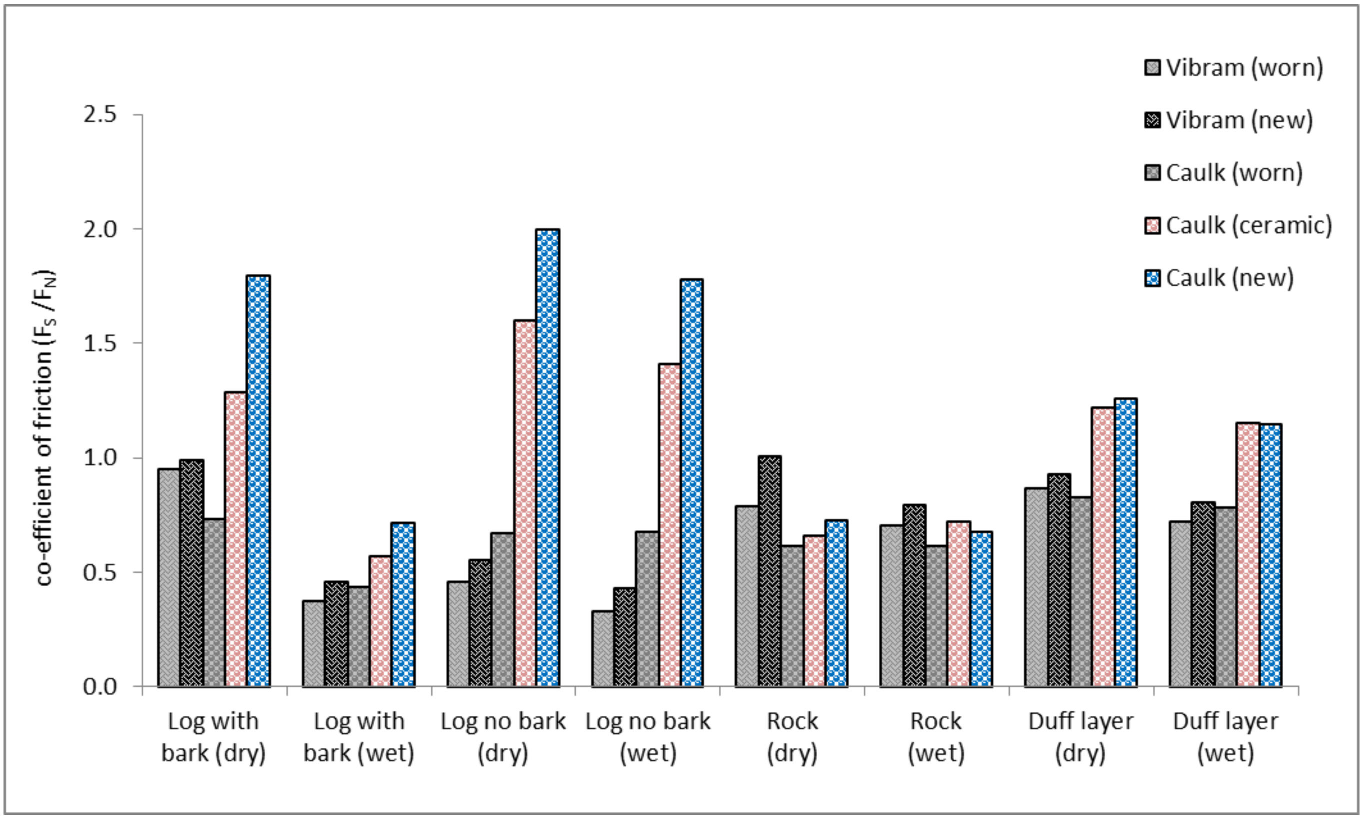

Figure 8. Boot traction test results

Caulk boots had a greater difference in traction between log and rock surfaces than non-caulk hiking boots. Therefore, much of the additional traction that caulks provide on logs would be lost when encountering bare rock surfaces, and the worker must compensate to maintain his or her safety. Also, the log-with-no-bark test was done by removing the bark from the log used in the log-with-bark test, leaving the bare log relatively clean. In actual conditions, a bare log may be covered with a thin organic film that could become very slippery for non-caulk boot treads in wet conditions.

An important consideration when caulk boots are selected for daily use is that the caulks must be properly maintained or they could become a safety risk when the caulks become old and worn.

CONCLUSION

- The test results indicate that caulk boots have better traction than non-caulk hiking boots on all log surfaces, as long as the caulks are in good condition. However, when caulks become worn, they have less traction than non-caulk hiking boots on many surfaces. So, if caulk boots are used, they must be properly maintained or they could become a safety risk when caulks become worn.
- Compared to non-caulk hiking boots, caulk boots have a greater difference in traction between log and rock surfaces, and workers must remain vigilant and make adjustments accordingly.
- New, non-caulk hiking boots have better traction than caulk boots on dry rock, but they have similar traction on wet rock.

- The ceramic caulk treads had a slightly lower traction than the new steel caulks reflecting a caulk profile that was similar to a mildly worn steel caulk with approximately 80% of the wear remaining. However, the ceramic caulk will remain at this level of wear for its entire lifespan.
- The type of ground surface is critical to making the correct choice for boot selection. However, caulk boots will generally have better traction than non-caulk hiking boots in most forest sites unless there is a high proportion of exposed rock surface in the work area.

RECOMMENDATIONS FOR FUTURE RESEARCH

This test measured static boot traction in a controlled environment and did not determine how other factors including slope, terrain roughness, slash level, and experience can affect slips, trips, and falls in workers. These measurements should be explored in a more comprehensive dynamic test under various field conditions.

APPENDIX: STATIC COEFFICIENT OF FRICTION OF THE BOOTS ON SIMULATED FOREST GROUND SURFACES

	Static coefficient of friction (µS = FS/FN)				
	Vibram (worn)	**Vibram (new)**	**Caulk (steel-worn)**	**Caulk (ceramic)**	**Caulk (steel-new)**
Log with bark (dry)	0.95	0.99	0.73	1.28	1.80
Log with bark (wet)	0.37	0.45	0.44	0.57	0.71
Log no bark (dry)	0.46	0.55	0.67	1.60	2.00
Log no bark (wet)	0.33	0.43	0.68	1.41	1.78
Rock (dry)	0.79	1.00	0.61	0.66	0.73
Rock (wet)	0.70	0.79	0.61	0.72	0.68
Duff layer[a] (dry)	0.86	0.93	0.82	1.22	1.26
Duff layer[a] (wet)	0.72	0.81	0.78	1.15	1.15

[a]Duff layer: The underside of commercial grass sod was used to simulate the forest duff layer under the litter layer.

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