Caulk Boot versus Hiking Boot: A Test of Traction

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INTRODUCTION

There is an ongoing question about the effectiveness and safety requirement for using caulk boots compared to non-caulk boots in silviculture work in the interior of British Columbia[1]. On the BC coast, silviculture workers use caulk boots almost exclusively, but in the interior they are not commonly used even though there are many situations where caulk boots may provide superior traction. Boot selection is often based on personal preference rather than facts. Additional information regarding the differences in traction of caulk boots and non-caulk boots on various forest ground surfaces, would help workers to 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 and non-caulk boots on four surfaces representing ground cover found in BC forests.

OBJECTIVES

The objectives of this test are to:

- measure the difference in traction between caulk boots and non-caulk boots on four surfaces (wet and dry) including log with bark, log with no bark, rock, and duff layer, and
- produce a quantitative measure of how the level of caulk and tread wear affects traction.

METHODS

An apparatus was built 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 (Figure 1) 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 remains stationary. The movement of the white mark in the picture indicates the short horizontal movement of the sliding floor (Figure 2). 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 (Figure 4) was used to read the horizontal tension in millivolts which was converted to kilograms. 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 (e.g. 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.

[1] *John Betts, personal communication, Nov. 11, 2014*

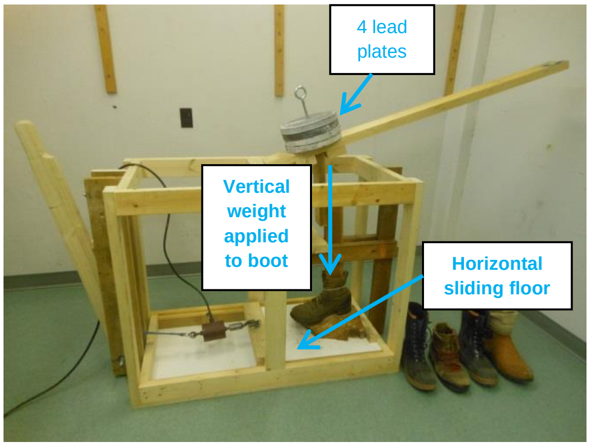

Figure 1. Boot traction testing apparatus

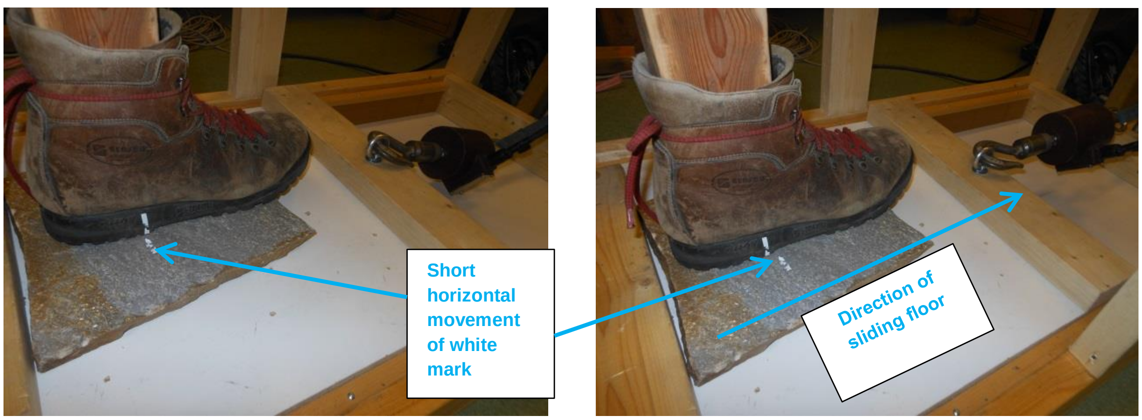

Figure 2. Horizontal movement of the sliding floor under a stationary hiking boot

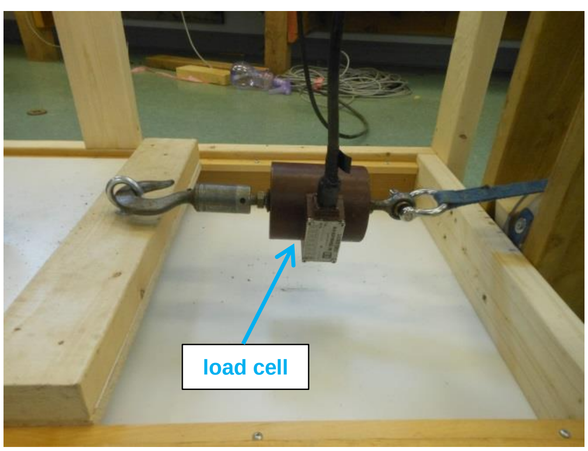

Figure 3. Load cell measuring horizontal tension

Figure 4. CR23X datalogger

Measurements were taken for five boots including a hiking boot with a worn Vibram tread (Figure 5a), a hiking boot with a new Vibram tread (Figure 5b), a caulk boot with worn steel caulks (Figure 6a), a caulk boot with new steel caulks (Figure 6b), and a caulk boot with ceramic caulks (Figure 6c). The worn Vibram treads were estimated to have approximately 40% of the tread remaining (Figure 5a), the worn steel caulks were estimated to have approximately 40% of the caulks remaining (Figure 6a) and the ceramic caulks remained at a consistent level of wear that was estimated to be similar to having 80% of the wear level of steel caulk treads (Figure 6c).

a) b)

Figure 5. a) worn Vibram tread, and b) new Vibram tread.

a) b) c)

Figure 6. a) Worn steel caulk boots, b) new steel caulk boots, c) ceramic caulk boots

Measurements were taken on four different surfaces including log with bark, log with no bark, rock, and a 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. So, 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. We were unable to measure traction on actual harvesting slash 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.

a) b) c) d)

Figure 7. a) log with bark, b) log with no bark, c) rock, and d) 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.

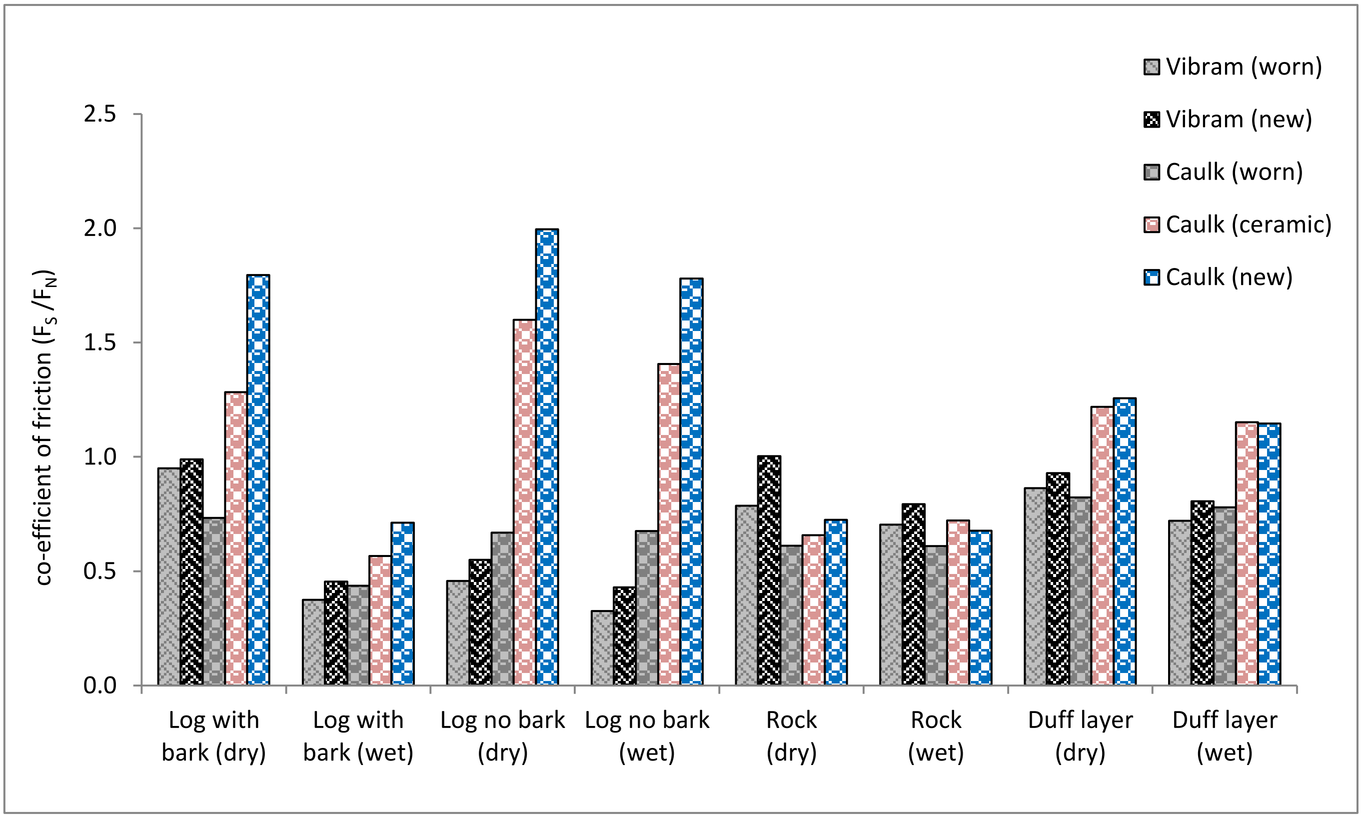

Figure 8. Boot traction test results

Caulks had a greater difference in traction between log and rock surfaces than hiking boots. This means the additional traction caulks provide on logs would be dramatically 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 hiking boot treads in wet conditions. Another important factor 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 caulk boots have better traction than hiking boots on all log surfaces as long as the caulks are in good condition. However, when caulks have become worn, they have less traction than 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 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 hiking boots have better traction than caulk boots on dry rock, but on wet rock, hiking boots and caulk boots have similar traction.
- The type of ground surface is critical to making the correct choice for boot selection. However, caulk boots will generally have better traction than 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

($\mu_S = F_S/F_N$)

	Vibram (worn)	Vibram (new)	Caulk (worn)	Caulk (ceramic)	Caulk (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[1] (dry)	0.86	0.93	*0.82*	*1.22*	*1.26*
Duff layer[1] (wet)	0.72	0.81	*0.78*	*1.15*	*1.15*

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

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