Coefficient of Friction of Dry Slash Pine and Southern Red Oak on Three Tension-Grip Facings

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ABSTRACT. A urethane material proved to have nine times higher static friction coefficient (0.9) than smooth steel (0.1) on radial and tangential wood surfaces pulled parallel to the grain. It is probably superior to 220-grit garnet paper or sand coatings for tension-grip facings in lumber testing machines.

THE COEFFICIENT OF FRICTION between two surfaces (μ) is defined as the ratio of horizontal force required to initiate motion between them to the vertical force holding them in contact (static friction), or the ratio to maintain constant velocity between the two (dynamic friction). The coefficient of static friction is always equal to, or greater than, the coefficient of dynamic friction.

This note reports a partial evaluation of three skid-resistant facings for preventing slippage in gripping jaws of equipment for tension tests of lumber. The data were obtained during a larger study with a wide variety of woods, and no attempt was made to explore the correlation between friction coefficient and pressure between grip facings.

As reference data, the coefficients of both static and dynamic friction were also determined on smooth steel. More extensive studies of wood-steel coefficients have been reported by Lemoine, et al.[1]

Effective grips prevent motion; a high static coefficient of friction is therefore desired, with ratio of static to dynamic coefficient near unity. When the coefficient of static friction is considerably higher than the dynamic coefficient, a phenomenon known as stick-slip occurs; i.e., the force required to initiate motion advances the specimen faster and further than the mechanical system requires. The specimen then stops while the mechanical system catches up.

Wood Samples

One-inch cubes of slash pine *(Pinus elliottii* var. *elliottii* Engelm.) and southern red oak *(Quercus falcata* Michx.) were cut to expose true radial and tangential surfaces. The tangential surface of the slash pine sample was latewood; the other surface exposed both earlywood and latewood. Surfaces were sanded smooth on 220-A grit garnet paper moved in a figure-eight pattern. Dust was removed with Freon-12 compressed gas.

Coefficients of friction were determined parallel to the grain orientation on the radial and tangential surfaces. Figure 1 illustrates sample surfaces and direction of slide.

Samples were tested at approximately 1 percent moisture content and 70° F.

[1]Lemoine, T. J., C. W. McMillin, and F. G. Manwiller. 1970. Wood variables affecting the friction coefficient of spruce pine on steel. Wood Sci. 2(3):144-148.

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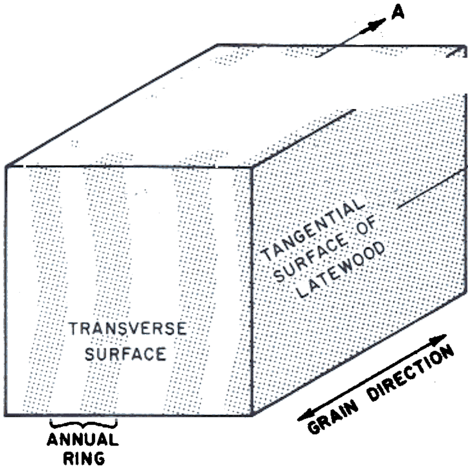

Figure 1. – Method of specimen preparation. The letter A refers to direction of slide, i.e., parallel to grain.

Skid-Resistant Facings

Four facings were studied:

1) A tool steel plate with a surface roughness of 9 microinches RMS.[2]
2) 220-grit garnet sandpaper.
3) Riehle testing machine "sand-coated" grip facing.
4) A sample of proprietary polyurethane, of 65-70 durometer hardness, manufactured by Griffith Polymers, Portland, Oreg. It was lent to us by M. D. Strickler, College of Engineering, Washington State University, who has applied it as grip facing on tension-testing equipment.

The steel and polyurethane surfaces were cleaned with water and petroleum ether (b.p. 30-60° C.). The Riehle jaw was cleaned with turpentine followed by soap and water. The sandpaper was used as received.

Procedure

Static determinations. – The wood block under test was placed on a stationary flat specimen of the facing material; from the block, a thin copper wire ran horizontally over a "frictionless" pulley and connected to a hanging metal container. Lead shot was added to the container until motion was initiated. The coefficient of static friction was calculated as the ratio of horizontal force (weight of container plus lead shot) to vertical force (weight of wood block plus approximately 1/4 lb. of top weight added). Determinations were replicated.

Dynamic determinations. – An Instron testing machine was used to measure the horizontal force required to maintain a constant 2-inch-per-minute motion of the wood block on the flat stationary surface. The test setup is described in Lemoine, et al.[1] Coefficient of dynamic friction was calculated as the ratio of the horizontal force (Instron load cell output) to vertical force (weight of wood block plus approximately 1/4 lb. of top weight). Stick-slip was severe on all material except the smooth steel. Estimation of average horizontal force was therefore difficult and not precise. Determinations were replicated.

Results and Discussion

The static coefficients on garnet paper, polyurethane, or Riehle jaw facings were 8 to 10 times those on smooth steel. Tangential surfaces of southern red oak had higher static coefficients than slash pine on the garnet paper and the polyurethane. On polyurethane the coefficients were equal to, or larger than, those on the other materials:

Wood species and material	Static coefficient (parallel to grain) On radial surfaces	On tangential surfaces
Slash pine		
Smooth steel	0.1	0.1
220-grit garnet paper	.9	.8
Griffith polyurethane	1.0	.9
Riehle jaw facing	.8	.9
Southern red oak		
Smooth steel	.1	.1
220-grit garnet paper	.9	.9
Griffith polyurethane	.9	1.0
Riehle jaw facing	.8	.9

[2]See Peters, C. C., and J. D. Cumming (1970. Measuring wood smoothness: A review. Forest Prod. J. 20(12):40-43) for a discussion of stylus-type techniques for surface evaluation, including voltage transducers.

Dynamic coefficient was 6 to 8 times greater for garnet paper, polyurethane, and Riehle jaw facings than for smooth steel:

Wood species and material	Dynamic coefficient (parallel to grain) On radial surfaces	On tangential surfaces
Slash pine		
Smooth steel	0.1	0.1
220-grit garnet paper	.7	.7
Griffith polyurethane	.8	.7
Riehle jaw facing	.6	.6
Southern red oak		
Smooth steel	.1	.1
220-grit garnet paper	.7	.8
Griffith polyurethane	.7	.7
Riehle jaw facing	.6	.6

Only on smooth steel was the static coefficient equal to the dynamic (so that the ratio of static to dynamic was 1.0). With the other materials, static coefficient was 10 to 50 percent more than dynamic, as follows:

Ratio of static to dynamic coefficient (parallel to grain)

Wood species and material	On radial surfaces	On tangential surfaces
Slash pine		
Smooth steel	1.0	1.0
220-grit garnet paper	1.3	1.1
Griffith polyurethane	1.2	1.3
Riehle jaw facing	1.3	1.5
Southern red oak		
Smooth steel	1.0	1.0
220-grit garnet paper	1.3	1.1
Griffith polyurethane	1.3	1.4
Riehle jaw facing	1.3	1.5

From these data it would appear that th polyurethane may be the best grip facing With it, the static coefficient is high, and th ratio of static to dynamic coefficient is fairl low (avg. 1.3).

Experience of M. D. Strickler a Washington State University supports thi conclusion. In application of polyurethane t the grips of a 200,000-pound tension machin he has observed no slippage when grips ar sufficiently tightened. He advises that th polyurethane should be cast directly onto th gripping jaws, rather than attached by glu bond. His experience with sandpaper-face grips has been less satisfactory.