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A Method For Measuring Slip Resistance On Footwear Designed For Snow and Ice

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Abstract: Industrial footwear suppliers offer a wide variety of traction aids designed specifically for use on snow and ice. An oversole is a supplemental attachment that is affixed to the work boot in order to enhance the traction offered by the sole of the boot. An overboot completely encases the work boot and offers its own enhanced-traction sole in addition to other benefits such as added warmth or waterproofing. Both forms of footwear typically have aggressively- treaded rubber soles that are designed to stay soft in cold temperatures. In addition, the tread often incorporates tungsten carbide studs to help increase traction on slippery walking surfaces. In the industrial setting, the worker often can encounter surfaces that are not homogeneously flat, that do not support the entire footprint, and may not permit the typical heel to toe foot contact experienced in normal walking. These kinds of surfaces offer challenges for investigating the traction aid's slip resistance. This paper reports on the methodology used to test the slip resistance of traction aid material on non-typical standing/walking surfaces such as ladder rungs, small platforms, and grated walkways. Slip resistance testing on two selected traction aids was conducted using the English XL Variable Incidence Tribometer. The surfaces were all made up of painted metal, both wet and dry, while a concrete surface was also tested for reference. Under all testing conditions, the slip resistance measurements for the traction aid material exceeded the 0.50 threshold for guiding the determination of walkway safety. Given that there are specific restrictions with slip resistance testing, there are numerous real-world scenarios that do not neatly fit within these restrictions. The method used in this testing may be helpful to expand the scope of slip resistance testing in the industrial setting.

Keywords: slip resistance, traction aid, tribology

1. Introduction

Utilization of traction aids in industry for outdoor, wintertime work is becoming more common. While this type of footwear had demonstrated benefits in walking performance on snow and ice, the authors set out to evaluate their effect on traction performance on other atypical surfaces consistent with ladders and grated platforms. These surfaces are typically metal, which is often painted. For the purposes of this study, traction performance is assessed in terms of slip resistance. Slip resistance is the relative force that resists the tendency of the shoe or foot to slide along the walkway surface (ANSI/ASSE A1264.1 2017). The authors set out to measure the slip resistance offered by two commonly used traction aids under conditions that are not typically conducive to performing field measurements. For example, the footwear material itself is being tested. Also, due to the configuration and shape of ladder and small platform structures, the use of a typical tribometer was problematic. To overcome these issues, slip resistance testing was performed in a lab setting, using the actual footwear material as well as samples of concrete and painted metal that were logistically better-suited for reliable and repeatable slip resistance testing.

2. Methods

2.1 Testing Protocol

To achieve reliable dynamic coefficient of friction tests, and to avoid adhesion and sticktion under wet testing conditions, slip resistance measurements were made using the English XL Variable Incidence Tribometer. The English XL VIT is a trusted biofedelic instrument that mimicks human ambulation. Measurements were made in accordance with

National Consensus Standards and generally accepted testing methods (ANSI/ASSE; ANSI/NFSI; English, 2003; Excel Tribometers, 2016; Grieser, 2002, 2016). Testing was performed under laboratory conditions, free of excessive humidity or temperature extremes. For each footwear material (neolite, oversole, and overboot) and each surface condition (dry concrete, dry painted metal, wet concrete, and wet painted metal) there were a total of eight slip resistance tests: four orthogonal directions each tested two times.

2.2 Independent Variables

Slip resistance is dependent upon may factors such as: material and condition of the walkway surface; material and condition of the shoe sole or heel material; the physical abilities of the user; the attempted or proposed activities of the user; and the presence of any contaminants on any or both of the surfaces, and other factors (ANSI/ASSE A1264.1 2017). In this study, the evaluation of slip resistance was dependent on: footwear heel material, walkway surface material, and walkway surface condition.

2.2.1 Footwear Heel Material

Figure 1. Oversole.

Figure 2. Overboot.

Figure 1 shows the oversole, which is worn over a typical steel toe work boot with raised heel. Figure 2 shows the overboot, which completely encases a typical steel toe work boot. For each piece of footwear, a circular piece of the rubber sole material, 1.25-inches in diameter, was cut from the heel-strike area. The circular samples were about 1/8” in thickness and the backs were cut smooth and flat so that they could be adhered to test foot blanks using high-strength double-sided tape. The direction of the tread pattern was noted and marked on the test foot blank so that it could be kept in the proper orientation during slip resistance measurements. A Neolite test foot was also used in order to provide a baseline for comparison. Neolite’s consistency and material stability make it the preferred material for slip resistance testing (ANSI/ASSE TR-A1264.3-2007).

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Figure 3. Testing on concrete surface.

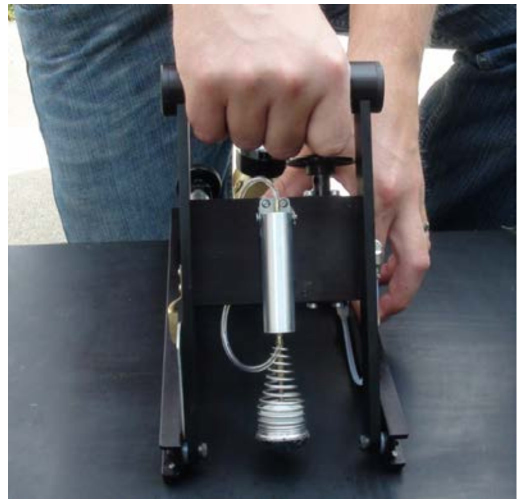

Figure 4. Testing on painted metal surface.

2.2.2 Walkway Surface Material

Each sole material was tested on a concrete paver that has been exposed to outdoor weather conditions for several years (Figure 3). The surface asperities closely resemble those of a typical concrete sidewalk. Each sole material was also tested on a piece of painted metal that has been exposed to outdoor weather conditions for several years (Figure 4). The painted surface has an unbroken finish.

2.2.3 Walkway Surface Condition

Each surface was free of dirt, dust, and other impurities. Dry testing was performed first, followed by wet testing using distilled water.

3. Results

The English Excel VIT gives static coefficient of friction values for dry testing. For wet testing, the results are referred to as slip resistance values. This is an important distinction from static coefficient of friction test machines, which can be prone to excessive residence time, or stiction. In general, the longer the residence time, the greater the adhesion that can occur, especially under wet testing conditions as the hydrodynamic squeezefilm is dissipated. This results in artificailly high friction values, and can best be avoided using a test device like the English XL VIT.

The slip resistance value of 0.50 is a generally accepted value for determining walkway safety. Although force plate testing has determined that the required slip resistance for normal ambulation is 0.25, with some studies suggesting values as high as 0.35, the 0.50 threshold incorporates an extra 0.15 – 0.25 factor of safety. This factor of safety helps to account for human and system variation. In other words, the 0.50 threshold is generally regarded as an acceptable level of risk. To put this in perspective, a slip resistance measurement of 0.50 on an English XL VIT is equivalent to the value 0.36 in a UK pendulum study which concluded that the risk for slipping during normal walking conditions would be 1:1,000,000 (English, 2003).

The traction aids performed very well on concrete and painted metal surfaces, both wet and dry. They met or exceeded the performance of the Neolite under all wet testing conditions. For dry testing conditions, the traction aids outperformed the Neolite under all conditions with the exception of the overboot on the concrete surface. In some instances, the slip resistance exceeded the measurability of the English XL VIT, which tops out at a slip resistance index of 1.0.

The Neolite test foot performed well under all conditions except for the wet painted metal. The measured result of 0.20 is similar to what one would measure on a dry icy surface (Figure 5). The standard deviation for all measurement conditions ranged from 0.02 to 0.03.

The oversole performed exceptionally on all surfaces, with a substantial increase in slip resistance for the painted metal surface (Figure 6). The standard deviation for all measurement conditions ranged from 0.00 to 0.02. The overboot also performed very well on all surfaces, providing the greatest level of slip resistance for the painted metal surface (Figure 7). The standard deviation for all measurement conditions ranged from 0.00 to 0.04.

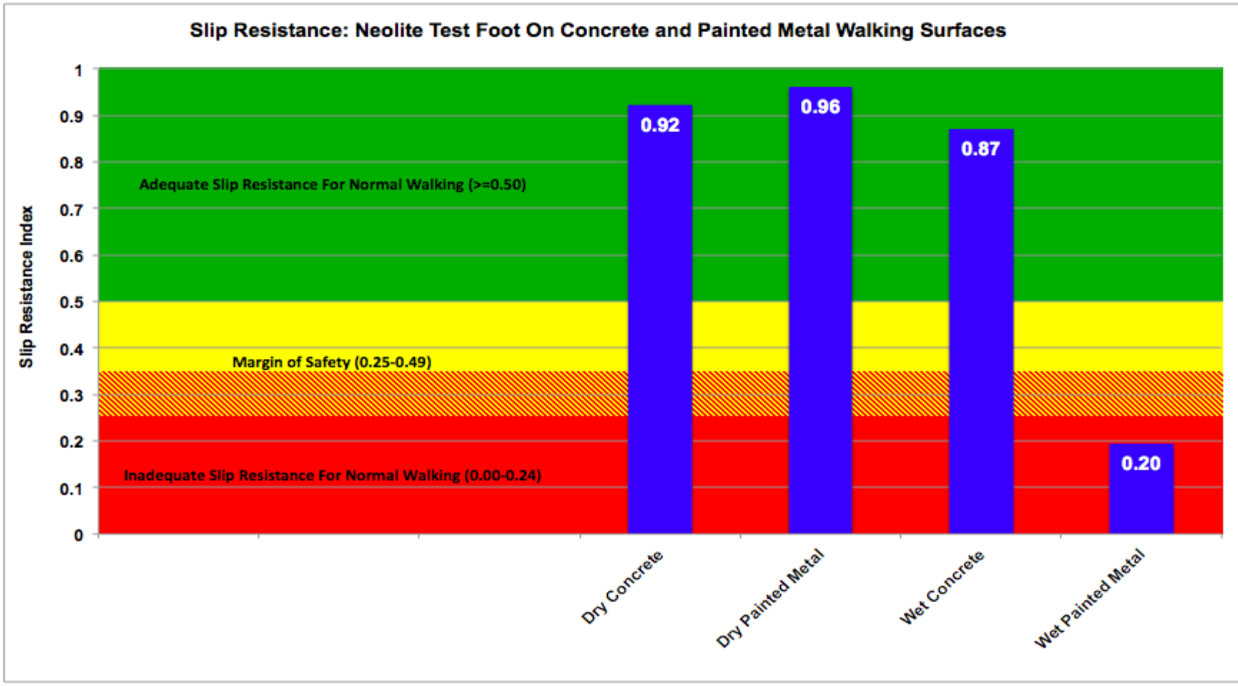

Figure 5. Neolite Test Foot On Concrete and Painted Metal Walking Surfaces

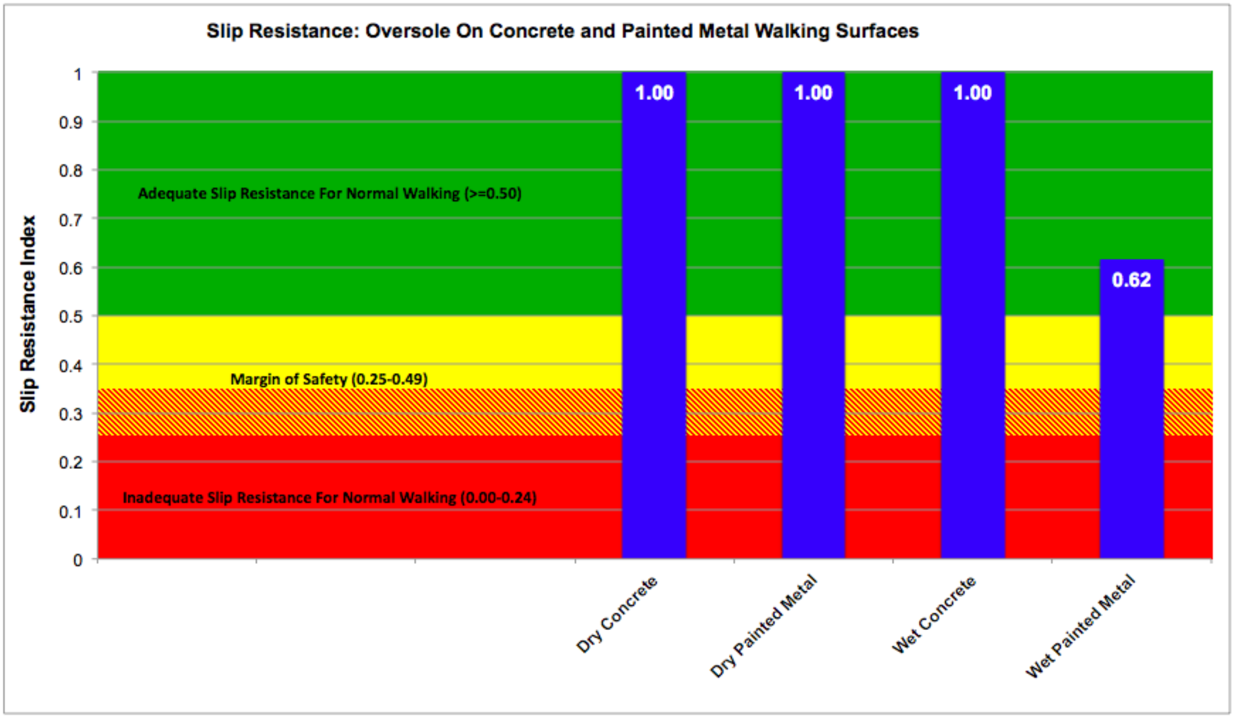

Figure 6. Oversole On Concrete and Painted Metal Walking Surfaces

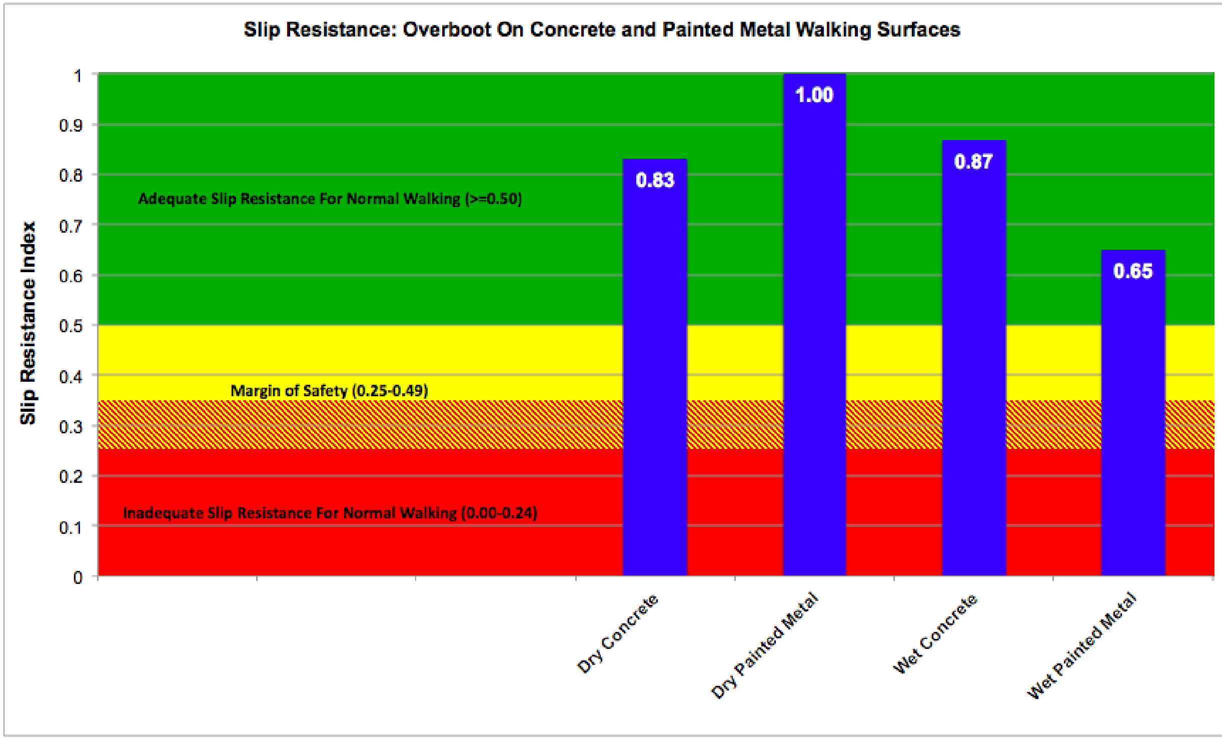

Figure 7. Overboot On Concrete and Painted Metal Walking Surfaces

4. Discussion

This methodology is consistent with that used for the testing of slip resistance on walkway surfaces but has been applied to gain some objective understanding of the slip resistance of traction aids when used for atypical walking conditions (i.e. on ladders and small platforms). Slip resistance testing for these types of conditions has not been previously reported. The results of this testing can help to better understand the performance of traction aids for various real-world conditions beyond walking on level surfaces. Additional study will help to support decision making toward recommending traction aids for winter conditions. In industry, while workers may walk on ground conditions of snow and ice, they also may need to be on various other types of surfaces within their outdoor industrial facility. It is believed that this first attempt to quantify the performance of traction aids, under atypical conditions, will support continued research.

Furthermore, this methodology could be expanded in future studies to include objective testing of various other elements of the traction aid. Some examples of other elements that could be tested include: the contour of forefoot and heel, the attachment mechanisms used by the traction aid to workboot, the tread patterns used, and the integration of studs into the tread. Regarding the results of this testing, the design of the traction aids incorporate the use of a soft rubber that remains pliable in cold weather conditions. It is believed that the softer rubber used in traction aids, though less durable than the sole of a typical workboot, improves conformity to surface asperities thus enhancing slip resistance. The traction aids tested provided a generally accepted threshold of safety for slip resistance under both wet and dry conditions (English, 2003).

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