

MODELLING AND MITIGATION OF UNEXPECTED SLIPS AND FALLS IN HOSPITALS

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**CENTRE FOR BIOMEDICAL ENGINEERING
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by

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Certificate

This is to certify that the dissertation entitled **Modelling and Mitigation of Unexpected Slips and Falls in Hospitals**, submitted by **Mr. Subhodip Chatterjee**, a Research Scholar, in the *Centre For Biomedical Engineering, Indian Institute of Technology, Delhi, India*, for the award of the degree of **Doctor of Philosophy**, is a record of an original research work carried out by him under my supervision and guidance. The dissertation fulfils all requirements as per the regulations of this Institute and in my opinion has reached the standard needed for submission. Neither this dissertation nor any part of this has been submitted for any degree or academic award elsewhere.



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Abstract

Slips and falls are major causes of workplace injuries around the globe. The cost of workplace accidents caused by trips, slips, and falls is expected to surpass \$6 billion annually in the USA. Above nine million incidents were treated in emergency rooms of hospitals as a result of slips, trips, and falls (STF), accounting greater than 25% of all non-life threatening workplace accidents in 2015. Out of these hospital slips, there is a big percent (37.3%) are due to barefoot slips in bathrooms and slips with standard footwear worn in hospitals. Thus we can observe the necessity of assessment of the slip risk across different floorings, especially in hospitals is imperative. Numerous tools based on friction assessments, commonly referred to as slipmeters, have been created to evaluate the slipperiness of floorings in hospitals. However, there have been no studies on barefoot slip risk assessment and limited works have been conducted on evaluation of footwear-floor slipperiness in hospitals. Also how the design of footwear especially in hospitals can affect the footwear-floor traction is unknown to date. Thus the major focus of this dissertation was to extensively model and assess the traction performance of hospital floorings in barefoot conditions and with standard and systematically modified footwear worn by hospital staff (i.e. nurses, doctors, trauma centre healthcare staff etc.).

The first chapter introduces the topic of slips and falls, followed by its worldwide effect and basic terminologies. The second chapter attempts to summarise the research work done till date on barefoot slip testing and footwear slip testing accompanied with the description of slip testers used till date. The focus of the third chapter was on the evaluation of the barefoot slip hazard in the presence of different flooring contaminants by employing a developed barefoot heel surrogate. The heel surrogate was made using a biofidelic elastomer that had previously been created by the scientists for simulating a human heel. The friction co-efficient was calculated and shown to be much lower for water applied, soapy, and oily flooring scenarios and to be maximum for the dry state. Similar barefoot risks were found on some flooring types with high COF correlations assessed for certain contaminants, such as matt finish and polished tile in wet conditions. The capacity to conduct such field studies using the innovative barefoot substitute or surrogate would be essential for choosing appropriate slip-resistant flooring for the avoidance of fall injuries caused due to slips.

The fourth chapter involved the application of the developed heel surrogate in assessing the slip risk in fifteen different bathroom flooring tiles present in the bathrooms intended for the

patients in the different wards of the All Indian Institute of Medical Science (AIIMS), New Delhi. The dry condition showed the highest available coefficient of friction (ACOF), followed by water applied and shampoo-contaminated conditions. The extremely reproducible nature across the different bathroom floorings and contaminants of the developed surrogate properties have been established. The probability of similar barefoot dangers on such flooring tiles is supported by high correlations between the ACOF of numerous flooring configurations for the shampoo contaminated situation. It was also noted that, particularly in the case of the shampoo spill scenario, the surface roughness was not a determining factor in evaluating the ACOF values on the flooring tiles. The fifth chapter involved the slip risk assessment of eight actual patient bathroom floorings present in the rehabilitation department of AIIMS, New Delhi. On transitioning from dry to contaminated circumstances, it was seen that the friction in the barefoot state significantly decreased. For all the contaminants, the floorings showing significant relationships were estimated. There were certain specific floor tiles that showed a similar pattern in the traction performance under wet, dry, shampoo, and shower gel-contaminated conditions. The evaluation of slip risk in these flooring tiles revealed a similar tendency in the fluctuation of the ACOF values. These findings shed light on the likelihood of barefoot slipping on various hospital bathroom floorings in the presence of widely available bathroom contaminants.

The transition from barefoot slip testing to footwear slip testing can be observed from Chapter-6, in which high selling formal footwear used by healthcare professionals such as nurses were evaluated for slip related injuries. Polyurethane replicas of the selected footwear outsoles were fabricated having the same outsole hardness as the original footwear. The British Pendulum Skid tester was selected as the instrument for slip testing. A heel connector was also fabricated for proper attachment of the outsoles to the tester. Outsoles with tread orientation along or oblique to the slip direction, exhibited comparatively high ACOF in water applied slipping conditions. Similar traction behaviour was observed for majority of the outsoles for liquid soap contaminated floorings, indicating generalizability of test results. The introduction of the robotic biofidelic and tribofidelic portable slip tester was the main highlight in Chapter-7. Ten Indian manufactured formal footwear majorly used by healthcare staff in AIIMS, New Delhi were selected for slip risk evaluation in major three hospital flooring tiles in the presence of water and floor cleaner. The findings of this study showed wide variances in the traction capabilities of the footwear under consideration, which raised the danger of slipping under fluid contamination circumstances. Across all the shoes tested on dry laminate and matt flooring,

contact area of the footwear treads was found to be an influencing parameter. Shoes with planar surface (i.e., wither plane or no variation in treads) at the heel region showed the lowest ACOF values. The correlations suggest that high contact areas might help mitigate the slip and fall risks. Shoes having low shore hardness (or soft shoes) showed increased slip-resistance across common slipping conditions. On the other hand, shoes having harder outsoles exhibited high slipping risks. Specifically, on smooth flooring, softer shoes helped increase the overall contact area to produce high ACOF values. Furthermore, softer shoes showed increased slip-resistant performance even on wet floorings.

In the first part of Chapter-8, the traction performance of systematically modified footwear was studied for the first time. Commonly utilised tread orientation such as horizontally oriented tread patterns found on the topography of the outsole of formal footwear which is worn by healthcare workers was examined. The tread channels were tested using a biofidelic slip testing apparatus while being parametrically changed across widths and gaps. It was discovered that parametrical changes in the horizontal tread patterns had an impact on how well the outsoles provided grip. On floors with fluid contamination, the total slipping risk may increase with outsoles that have larger treads and smaller gaps. While outsoles with bigger gaps displayed higher traction when slipping on wet floors, smaller tread widths created higher traction when slipping on dry surfaces. In the second part of Chapter-8, the traction performance of commonly utilised tread orientation such as vertically oriented tread patterns found on the topography of the outsole of formal footwear which is also worn by healthcare workers was examined. The tread channels were tested using a biofidelic slip testing apparatus while being parametrically changed across widths and gaps. Overall, it was observed that proportional adjustments in vertical tread patterns had a considerable impact on how well shoes grip wet and dry surfaces when slipping. On dry floors, outsoles with wide treads and close spacing can reduce the overall danger of slipping, and vice versa. Outsoles with large tread gaps may further aid in improving overall grip performance on wet surfaces. In comparison to contact tread region area, tread gaps were determined to be the dominant factor in offering sufficient footwear-floor grip in slippery water applied circumstances.

In Chapter-9, the focus was on understanding the effect of different accessible slip-resistant floor coating systems especially intended for hospital floorings to reduce slip related accidents. Three floor coatings were evaluated for five safety footwear implemented by trauma centre healthcare workers, including acid-based etchant solution, epoxy floor paint, and polyurethane. A biofidelic and mobile automatic slip testing device was used to evaluate the coated floorings

in dry conditions as well as in the vicinity of water and machine oil as contaminants. It was found that in dry conditions, flooring with etchant coating significantly improved in terms of slip resistance. It was discovered that epoxy coated flooring improved overall traction effectiveness in water-contaminated conditions. Flooring with a polyurethane coating demonstrated excellent slip resistance in all slipping scenarios, hence can be implemented for hospital floorings.

The overall objective of this dissertation was to understand the traction characteristics of the human barefoot, through the usage of the heel surrogate and British Pendulum Skid tester in a hospital setting and then moving towards footwear slip testing and understanding the effect of tread designs on traction by employing the similar testing device and the novel robotic biofidelic and tribofidelic portable slip tester for footwear worn by nurses, doctors and other hospital staff. An overall understanding of the foot-floor traction and its implication on slips and falls in hospitals in India were established in this dissertation. Development of interventions for mitigation of the slip related injuries in hospital floorings were also a key positive factor in this dissertation, as a number of tread patterns, floorings, floor coatings and footwear were identified which could potentially enhance slip resistance in hospital floorings.

अमूर्त

दुनिया भर में कार्यस्थल पर फिसलन और गिरना चोटों का प्रमुख कारण है। संयुक्त राज्य अमेरिका में यात्रा, फिसलन और गिरने के कारण होने वाली कार्यस्थल दुर्घटनाओं की लागत सालाना 6 अरब डॉलर से अधिक होने की उम्मीद है। फिसलने और गिरने (एसटीएफ) के परिणामस्वरूप अस्पतालों के आपातकालीन कक्षों में नौ मिलियन से अधिक घटनाओं का इलाज किया गया, जो 2015 में सभी गैर-जीवन-घातक कार्यस्थल दुर्घटनाओं का 25% से अधिक था। इन अस्पताल पर्वियों में से, एक बड़ा प्रतिशत (37.3%) बाथरूम में नंगे पैर फिसलने और अस्पतालों में पहने जाने वाले मानक जूते के साथ फिसलने के कारण होता है। इस प्रकार हम देख सकते हैं कि विभिन्न फर्शों पर, विशेषकर अस्पतालों में स्लिप जोखिम के आकलन की आवश्यकता अनिवार्य है। अस्पतालों में फर्श की फिसलन का मूल्यांकन करने के लिए घर्षण मूल्यांकन पर आधारित कई उपकरण, जिन्हें आमतौर पर स्लिपमीटर कहा जाता है, बनाए गए हैं। हालाँकि, नंगे पाँव फिसलन के जोखिम मूल्यांकन पर कोई अध्ययन नहीं किया गया है और अस्पतालों में जूते-फर्श की फिसलन के मूल्यांकन पर सीमित कार्य किए गए हैं। यह भी आज तक अज्ञात है कि विशेष रूप से अस्पतालों में जूते का डिज़ाइन जूते-फर्श के कर्षण को कैसे प्रभावित कर सकता है। इस प्रकार इस शोध प्रबंध का मुख्य फोकस नंगे पैर की स्थिति में और अस्पताल के कर्मचारियों (यानी नर्सों, डॉक्टरों, ट्रॉमा सेंटर हेल्थकेयर स्टाफ आदि) द्वारा पहने जाने वाले मानक और व्यवस्थित रूप से संशोधित जूते के साथ अस्पताल के फर्श के कर्षण प्रदर्शन का व्यापक रूप से मॉडल और आकलन करना था।

पहला अध्याय फिसलन और गिरावट के विषय का परिचय देता है, इसके बाद इसके विश्वव्यापी प्रभाव और बुनियादी शब्दावली का परिचय देता है। दूसरे अध्याय में आज तक उपयोग किए गए स्लिप परीक्षकों के विवरण के साथ नंगे पैर पर्वी परीक्षण और फुटवियर पर्वी परीक्षण पर अब तक किए गए शोध कार्य को संक्षेप में प्रस्तुत करने का प्रयास किया गया है। तीसरे अध्याय का फोकस एक विकसित नंगे पैर एड़ी सरोगेट को नियोजित करके विभिन्न फर्श संदूषकों की उपस्थिति में नंगे पैर फिसलने के खतरे के मूल्यांकन पर था। हील सरोगेट एक बायोफिडेलिक इलास्टोमेर का उपयोग करके बनाया गया था जिसे पहले वैज्ञानिकों द्वारा मानव एड़ी का अनुकरण करने के लिए बनाया गया था। घर्षण गुणांक की गणना की गई और इसे पानी, साबुन और तैलीय फर्श परिदृश्यों के लिए बहुत कम और शुष्क अवस्था के लिए अधिकतम दिखाया गया। इसी तरह के नंगे पैर जोखिम कुछ प्रकार के फर्शों पर पाए गए, जिनमें कुछ संदूषकों के लिए उच्च सीओएफ सहसंबंध का मूल्यांकन किया गया था, जैसे कि मैट फ़िनिश और गीली स्थितियों में

पॉलिश टाइल। इसी तरह के नंगे पैर जोखिम कुछ प्रकार के फर्शों पर पाए गए, जिनमें कुछ संदूषकों के लिए उच्च सीओएफ सहसंबंध का मूल्यांकन किया गया था, जैसे कि मैट फ़िनिश और गीली स्थितियों में पॉलिश टाइल। फिसलन के कारण गिरने वाली चोटों से बचने के लिए उपयुक्त फिसलन प्रतिरोधी फर्श चुनने के लिए नवीन नंगे पाँव विकल्प या सरोगेट का उपयोग करके ऐसे क्षेत्र अध्ययन करने की क्षमता आवश्यक होगी।

चौथे अध्याय में अखिल भारतीय आयुर्विज्ञान संस्थान (एम्स), नई दिल्ली के विभिन्न वार्डों में मरीजों के लिए बाथरूम में मौजूद पंद्रह अलग-अलग बाथरूम फर्श टाइल्स में स्लिप जोखिम का आकलन करने में विकसित हील सरोगेट का अनुप्रयोग शामिल था। शुष्क स्थिति में घर्षण का उच्चतम उपलब्ध गुणांक (एसीओएफ) दिखाया गया, इसके बाद पानी लगाया गया और शैम्पू-दूषित स्थिति देखी गई। विभिन्न बाथरूम फर्शों और विकसित सरोगेट संपत्तियों के संदूषकों में अत्यधिक प्रतिलिपि प्रस्तुत करने योग्य प्रकृति स्थापित की गई है। ऐसी फर्श टाइल्स पर समान नंगे पाँव खतरों की संभावना को शैम्पू दूषित स्थिति के लिए विभिन्न फर्श विन्यासों के एसीओएफ के बीच उच्च सहसंबंधों द्वारा समर्थित किया जाता है। यह भी नोट किया गया कि, विशेष रूप से शैम्पू स्पिल परिसदृश्य के मामले में, फर्श टाइल्स पर एसीओएफ मूल्यों के मूल्यांकन में सतह खुरदरापन एक निर्धारण कारक नहीं था। पाँचवें अध्याय में एम्स, नई दिल्ली के पुनर्वास विभाग में मौजूद आठ वास्तविक रोगी बाथरूम फर्शों का स्लिप जोखिम मूल्यांकन शामिल था। शुष्क से दूषित परिस्थितियों में संक्रमण करने पर, यह देखा गया कि नंगे पैर अवस्था में घर्षण काफी कम हो गया। सभी संदूषकों के लिए, महत्वपूर्ण संबंध दर्शाने वाले फर्शों का अनुमान लगाया गया। कुछ विशिष्ट फर्श टाइलें थीं जो गीली, सूखी, शैम्पू और शॉवर जेल-दूषित स्थितियों के तहत कर्षण प्रदर्शन में समान पैटर्न दिखाती थीं। इन फर्श टाइलों में फिसलन जोखिम के मूल्यांकन से ACOF मूल्यों के उतार-चढ़ाव में समान प्रवृत्ति का पता चला। ये निष्कर्ष व्यापक रूप से उपलब्ध बाथरूम संदूषकों की उपस्थिति में विभिन्न अस्पताल के बाथरूम फर्शों पर नंगे पैर फिसलने की संभावना पर प्रकाश डालते हैं।

नंगे पाँव स्लिप परीक्षण से फुटवियर स्लिप परीक्षण में परिवर्तन को अध्याय-6 से देखा जा सकता है, जिसमें नर्सों जैसे स्वास्थ्य पेशेवरों द्वारा उपयोग किए जाने वाले उच्च बिक्री वाले औपचारिक जूते का मूल्यांकन स्लिप से संबंधित चोटों के लिए किया गया था। चयनित फुटवियर आउटसोल की पॉलीयुरेथेन प्रतिकृतियां मूल फुटवियर के समान आउटसोल कठोरता के साथ निर्मित की गईं। ब्रिटिश पेंडुलम स्किड परीक्षक को स्लिप परीक्षण के लिए उपकरण के रूप में चुना गया था। परीक्षक के आउटसोल के उचित जुड़ाव के लिए एक हील कनेक्टर भी बनाया गया था। स्लिप दिशा के साथ या तिरछे चलने वाले आउटसोल,

पानी में फिसलन की स्थिति में तुलनात्मक रूप से उच्च ACOF प्रदर्शित करते हैं। तरल साबुन से दूषित फर्श के अधिकांश आउटसोल में समान कर्षण व्यवहार देखा गया, जो परीक्षण परिणामों की सामान्यता का संकेत देता है। अध्याय-7 में रोबोटिक बायोफिडेलिक और ट्राइबोफिडेलिक पोर्टेबल स्लिप टेस्टर की शुरुआत मुख्य आकर्षण थी। एम्स, नई दिल्ली में स्वास्थ्य देखभाल कर्मचारियों द्वारा प्रमुख रूप से उपयोग किए जाने वाले दस भारतीय निर्मित औपचारिक जूतों को पानी और फर्श क्लीनर की उपस्थिति में अस्पताल के प्रमुख तीन फर्श टाइल्स में फिसलन जोखिम मूल्यांकन के लिए चुना गया था। इस अध्ययन के निष्कर्षों ने विचाराधीन जूते की कर्षण क्षमताओं में व्यापक भिन्नताएं दिखाईं, जिससे द्रव संदूषण परिस्थितियों में फिसलने का खतरा बढ़ गया। सूखे लैमिनेट और मैट फर्श पर परीक्षण किए गए सभी जूतों में, जूते के धागों का संपर्क क्षेत्र एक प्रभावशाली पैरामीटर पाया गया। एड़ी क्षेत्र में सपाट सतह वाले जूते (यानी, मुरझाए हुए समतल या पैरों में कोई भिन्नता नहीं) ने सबसे कम ACOF मान दिखाया। सहसंबंधों से पता चलता है कि उच्च संपर्क क्षेत्र फिसलन और गिरावट के जोखिम को कम करने में मदद कर सकते हैं। कम किनारे की कठोरता वाले जूते (या नरम जूते) ने सामान्य फिसलन स्थितियों में फिसलन-प्रतिरोध में वृद्धि देखी। दूसरी ओर, सख्त तलवों वाले जूतों के फिसलने का जोखिम अधिक होता है। विशेष रूप से, चिकने फर्श पर, नरम जूतों ने उच्च ACOF मान उत्पन्न करने के लिए समग्र संपर्क क्षेत्र को बढ़ाने में मदद की। इसके अलावा, नरम जूतों ने गीले फर्श पर भी फिसलन-प्रतिरोधी प्रदर्शन को बढ़ाया।

अध्याय-8 के पहले भाग में पहली बार व्यवस्थित रूप से संशोधित जूते के कर्षण प्रदर्शन का अध्ययन किया गया था। आम तौर पर उपयोग किए जाने वाले ट्रेड ओरिएंटेशन जैसे कि स्वास्थ्य कर्मियों द्वारा पहने जाने वाले औपचारिक जूते के आउटसोल की स्थलाकृति पर पाए जाने वाले क्षैतिज रूप से उन्मुख ट्रेड पैटर्न की जांच की गई। ट्रेड चैनलों का परीक्षण बायोफिडेलिक स्लिप परीक्षण उपकरण का उपयोग करके किया गया था, जबकि चौड़ाई और अंतराल में पैरामीट्रिक रूप से बदला गया था। यह पाया गया कि क्षैतिज ट्रेड पैटर्न में पैरामीट्रिक परिवर्तनों का इस बात पर प्रभाव पड़ा कि आउटसोल कितनी अच्छी पकड़ प्रदान करते हैं। द्रव संदूषण वाले फर्श पर, बड़े तलवों और छोटे अंतराल वाले आउटसोल के साथ कुल फिसलने का जोखिम बढ़ सकता है। जबकि बड़े अंतराल वाले आउटसोल गीले फर्श पर फिसलते समय अधिक कर्षण प्रदर्शित करते हैं, छोटी चलने की चौड़ाई सूखी सतहों पर फिसलते समय अधिक कर्षण उत्पन्न करती है। अध्याय-8 के दूसरे भाग में, आमतौर पर उपयोग किए जाने वाले ट्रेड ओरिएंटेशन के कर्षण प्रदर्शन की जांच की गई, जैसे कि औपचारिक जूते के आउटसोल की स्थलाकृति पर पाए जाने वाले लंबवत उन्मुख ट्रेड पैटर्न, जो स्वास्थ्य देखभाल श्रमिकों द्वारा भी पहने जाते हैं। ट्रेड चैनलों का परीक्षण बायोफिडेलिक स्लिप परीक्षण उपकरण का उपयोग करके किया गया था, जबकि चौड़ाई और अंतराल

में पैरामीट्रिक रूप से बदला गया था। कुल मिलाकर, यह देखा गया कि ऊर्ध्वाधर चलने के पैटर्न में आनुपातिक समायोजन का इस बात पर काफी प्रभाव पड़ा कि फिसलते समय जूते गीली और सूखी सतहों पर कितनी अच्छी तरह पकड़ते हैं। सूखे फर्श पर, चौड़े धागों और कम दूरी वाले आउटसोल फिसलने के समग्र खतरे को कम कर सकते हैं, और इसके विपरीत भी। बड़े ट्रेड गैप वाले आउटसोल गीली सतहों पर समग्र पकड़ प्रदर्शन को बेहतर बनाने में मदद कर सकते हैं। संपर्क ट्रेड क्षेत्र क्षेत्र की तुलना में, फिसलने वाले पानी के उपयोग की परिस्थितियों में फुटवियर-फर्श पर पर्याप्त पकड़ प्रदान करने में ट्रेड गैप प्रमुख कारक के रूप में निर्धारित किया गया था।

इस शोध प्रबंध का समग्र उद्देश्य अस्पताल की सेटिंग में एड़ी सरोगेट और ब्रिटिश पेंडुलम स्किड परीक्षक के उपयोग के माध्यम से मानव नंगे पैर की कर्षण विशेषताओं को समझना था और फिर फुटवियर स्लिप परीक्षण की ओर बढ़ना और नर्सों, डॉक्टरों और अन्य अस्पताल कर्मचारियों द्वारा पहने जाने वाले जूते के लिए समान परीक्षण उपकरण और उपन्यास रोबोटिक बायोफिडेलिक और ट्राइबोफिडेलिक पोर्टेबल स्लिप परीक्षक को नियोजित करके कर्षण पर ट्रेड डिजाइन के प्रभाव को समझना था। इस शोध प्रबंध में फुट-फ्लोर ट्रेक्शन की समग्र समझ और भारत में अस्पतालों में फिसलने और गिरने पर इसके प्रभाव को स्थापित किया गया था। अस्पताल के फर्शों में फिसलन संबंधी चोटों को कम करने के लिए हस्तक्षेप का विकास भी इस शोध प्रबंध में एक महत्वपूर्ण सकारात्मक कारक था, क्योंकि कई ट्रेड पैटर्न, फर्श, फर्श कोटिंग्स और जूते की पहचान की गई थी जो संभावित रूप से अस्पताल के फर्शों में फिसलन प्रतिरोध को बढ़ा सकते थे।

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List of Abbreviations

Abbreviation	Meaning
ACOF	Available Coefficient of Friction
ANOVA	Analysis of Variance
AIIMS	All Indian Institute of Medical Science
ASTM	American Society for Testing and Materials
BLS	Bureau of Labor Statistics
BMI	Body Mass Index
BPT	British Pendulum Tester
BPST	British Portable Skid tester
COP	Centre of Pressure
COF	Coefficient of Friction
CAD	Computer Aided Design
DCOF	Dynamic Coefficient of Friction
EA	Elderly Aged
FF	Formal Footwear
Fv1 and Fv2	Normal Forces
Fx, Fy, and Fz	Ground Response Forces
GRF	Ground Reaction Force
HPS	Horizontal Pull Slipmeter
HOV	Homogeneous Vinyl
HTV	Heterogeneous Vinyl
HP	Horizontal Patterns
ICU	Intensive Care Unit
K1,K2,K3,K4,K5	Designation of Safety Shoes
MA	Middle Aged
NSC	National Safety Council
NSR	Non-Slip Resistant
OPD	Outpatient Department
PAST	Portable Articulated Strut Tribometer

PFT	Portable Friction Tester
PSS	Peak sliding speed
p	Profiled
PU	Polyurethane
PLA	Polylactic Acid
RCOF	Required Coefficient of Friction
Ra	Average Surface Roughness
r	Rough
S	Smooth
Sr	Slightly Rough
SR	Slip Resistant
SS	Slip Start
SLS	Sodium Laurel Sulphate
STF	Slip, Trip and Falls
SCOF	Static Coefficient of Friction
SEM	Scanning Electron Microscopy
TNO	Toegepast Natuurwetenschappelijk Onderzoek
TPU	Thermoplastic Polyurethane
UK	United Kingdom
vr	Very Rough
V0	Initial Velocity
VGRF	Vertical Ground Reaction Force
VP	Vertical Patterns
WLI	White Light Interferometry

List of Symbols

Symbols	Meaning
r	Sample Correlation Coefficient
R	Correlation coefficient
p	Probability Value
η^2_{partial}	Percentage of the variance in the dependent variable explained by the independent variables in a sample.
R^2	Coefficient of Determination
t	Ratio of the departure of the estimated value of a parameter from its hypothesized value to its standard error
cP	Centipoise