Assessing the slip resistance of flooring

A technical information sheet

Introduction

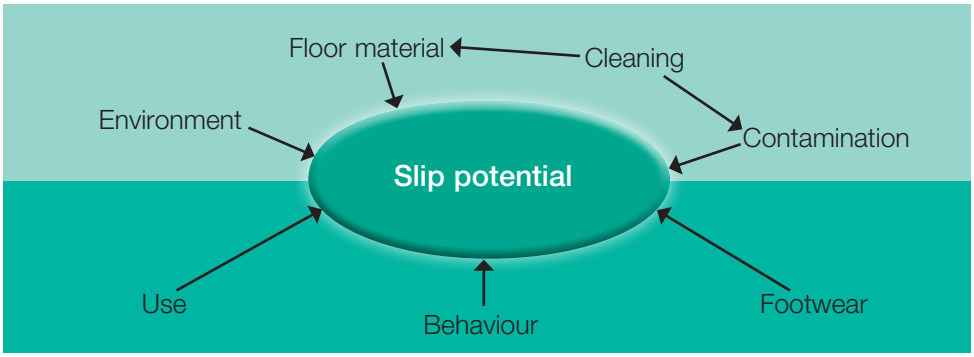
This technical information sheet looks at a number of test methods for assessing floor slip resistance and describes those HSE and the Health and Safety Laboratory (HSL) use in more detail. It is aimed at employers who need to perform accurate measurements of floor slipperiness, such as manufacturers and research and testing bodies. It will also help employers and other dutyholders assess slip risks in workplaces by helping them interpret flooring manufacturers' test data. This should allow them to make an informed decision when they choose new floors or monitor existing floors.

Background

Slips and trips are the most common cause of injury at work. On average, they cause over a third of all major injuries and over 40% of all reported injuries to members of the public. HSE statistics suggest that most of these accidents are slips, most of which happen when floor surfaces are contaminated (water, talc, grease, etc).

Research by HSL for HSE has shown that a combination of factors can contribute to slip accidents. HSL has developed a slip potential model, which identifies the important factors contributing to a slip (see Figure 1).

Figure 1 Slip potential model



The information sheet describes methods of assessing the slipperiness of floors. It aims to give employers enough information to select a method to test the slipperiness of the floor and interpret the results.

Assessment of slipperiness: The HSE approach

The Workplace (Health, Safety and Welfare) Regulations 1992[1] require floors to be suitable, in good condition and free from obstructions. People must be able to move around safely.

Research carried out by HSL, in conjunction with the UK Slip Resistance Group (UKSRG) and the British Standards Institution, has shown that commercially available, portable scientific test instruments can accurately assess the slipperiness of flooring materials.

HSL has developed a reliable and robust test method using these instruments to assess floor surface slipperiness. The method has been used as the basis of HSE and local authority advice and enforcement action.

The methodology is based on using two instruments:

- a pendulum, used in the pendulum coefficient of friction (CoF) test (HSE's preferred method of slipperiness assessment, see Figure 2);
- a surface microroughness meter (see Figure 3).

Figure 2 The pendulum CoF test

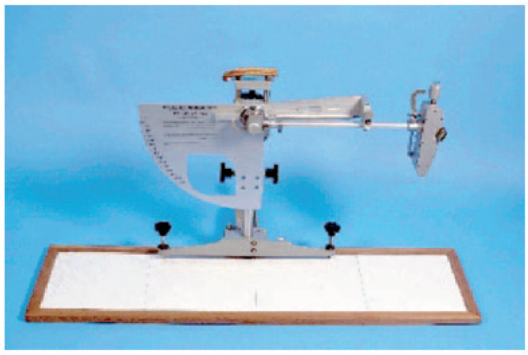


Figure 3 Surface microroughness meters
(left to right: Mitutoyo Surftest SJ201P, Surtronic Duo and Surtronic 25)

This methodology is ideally suited to both laboratory-based assessment, and for use on installed floors.

Pendulum

The pendulum CoF test (also known as the portable skid resistance tester, the British pendulum, and the TRRL pendulum, see Figure 2) is the subject of a British Standard, BS 7976: Parts1-3, 2002.[2]

The method is based on a swinging, imitation heel (using a standardised rubber soling sample), which sweeps over a set area of flooring in a controlled manner. The slipperiness of the flooring has a direct and measurable effect on the pendulum test value (PTV) given.

The preparation of the standard rubber sliders is detailed in BS 7976: Parts1-3, 2002 and the UKSRG guidelines.[3] There is a small difference between the two methods of slider preparation, and in certain limited situations the two methods may give slightly different results. HSE and the UKSRG believe the changes in the latest version of the UKSRG guidelines (2011) give the most useful results.

Research has confirmed the pendulum to be a reliable and accurate test, so HSE has adopted it as its standard test method for assessing floor slipperiness in both dry and contaminated conditions. However, to use it reliably, it needs to be operated and interpreted by a suitably trained and competent person. For profiled floors, several tests in different directions may be required to obtain a good understanding of profiled surfaces. So, only an experienced operator should assess these types of floors.

Interpretation of pendulum results

Pendulum results should be interpreted using the information reproduced in Table 1 (from UKSRG, 2011).

Table 1 Slip potential classification, based on pendulum test values (PTV)

	PTV
High slip potential	0-24
Moderate slip potential	25-35
Low slip potential	36 +

Practical considerations

Using Slider 96 rubber gives enough information for assessing slipperiness for shod pedestrians. For assessing barefoot areas, use Slider 55 rubber and for profiled flooring it may be helpful to use both slider materials.

The pendulum test equipment is large and heavy, so consider the manual handing of the equipment carefully for testing in the field.

Surface microroughness

An indication of slipperiness in water-contaminated conditions may be simply obtained by measuring the surface roughness of flooring materials. Roughness measurements may also be used to monitor changes in floor surface characteristics, such as wear. Research has shown that measuring the Rz parameter allows slipperiness to be predicted for a range of common materials. Rz is a measure of total surface roughness, calculated as the mean of several peak-to-valley measurements.

Interpretation of surface roughness

When surface microroughness data is used to supplement pendulum test data, the roughness results should be interpreted using the information reproduced in Table 2 (from UKSRG, 2011). Where only roughness data is available, use it in conjunction with the Slips Assessment Tool (SAT) detailed below.

Table 2 Slip potential classification, based on Rz microroughness values (applicable for water-wet pedestrian areas)

Rz surface roughness	**Slip potential**
Below 10 µm	High
10-20 µm	Moderate
20 + µm	Low

Practical considerations: Roughness meters

Research has shown that the Rz roughness parameter gives a good indication of floor slipperiness in water-contaminated conditions. The measurement of Rz using a hand-held meter is simple and quick. Roughness meters (see Figure 3) are unsuitable for use on carpet, undulating or very rough floors.

The figures quoted in Table 2 relate to floor surface slipperiness in water-contaminated conditions. If there are other contaminants, different levels of roughness will be needed to lower slip potential. As a general rule, a higher level of surface roughness is needed to maintain slip resistance with a more viscous (thicker) contaminant.

Slips assessment tool (SAT)

HSE and HSL have produced a PC-based software package to help users to carry out a slip risk assessment of level pedestrian walkway surfaces. SAT prompts the user to collect surface microroughness data from the test area, using a hand-held meter. SAT supplements the surface microroughness data (Rz) with other relevant information from the pedestrian slip potential model. This includes the causes of floor surface contamination, the regimes used to clean the floor surface (both in terms of their effectiveness and frequency), footwear types worn in the area, along with associated human factors and environmental factors. On completion, SAT supplies a slip risk classification; this indicates the potential for a slip. SAT is designed to help in the decision-making process when considering the risk of slipping in a defined area, and can be used iteratively to show the influence of different control measures. However, do not rely on it when considering the performance of just the flooring; in this instance a suitable CoF test should be used. The SAT software can be downloaded free at www.hse.gov.uk/slips/sat/index.htm.

The HSL ramp test

The HSL ramp test (Figure 4) is designed to simulate the conditions commonly encountered in typical workplace slip accidents. This uses clean water as the contaminant and footwear with a standardised soling material. Barefoot testing may also be undertaken. The test method involves using test subjects who walk forwards and backwards over a contaminated flooring sample. The inclination of the sample is increased gradually until the test subject slips. The average angle of inclination at which slip occurs is used to calculate the CoF of the flooring. The CoF measured relates to the flooring used on a level surface. It is possible to assess bespoke combinations of footwear, flooring and contamination, relating to specific environments, using this method. HSL also uses the ramp to assess the slipperiness of footwear.

Figure 4 The UKSRG ramp CoF test

Other ramp tests

Many European flooring manufacturers use ramp-type tests to classify the slipperiness of their products before sale. Such tests are generally carried out using German National Standard test methods (DIN 51097:1992[4] and DIN 51130:2004[5]).

DIN 51097 uses barefoot operators with a soap solution as the contaminant, and DIN 51130 uses heavily-cleated EN:ISO 20345 safety boots with motor oil contamination. HSE has reservations about these test methods, as neither uses contaminants that are representative of those commonly found in workplaces and the way the results are reported and applied (see below) is a cause for concern.

Floor surface materials are often classified on the basis of the DIN standards. The classification schemes outlined in DIN 51130 (Table 3) and DIN 51097 (Table 4) have led to some confusion, sometimes resulting in the wrong floor surfaces being installed.

Table 3 DIN 51130 R-Value slipperiness classification

Classification	R9	R10	R11	R12	R13
Slip angle (º)	6-10	10-19	19-27	27-35	> 35

Table 4 DIN 51097 slipperiness classification

Classification	A	B	C
Slip angle (º)	12-17	18-23	> 24

The R scale runs from R9 to R13, where R9 is slippery when wet, and R13 the least slippery. Floor surfaces that are classified by the DIN 51130 standard as R9 (or in some instances R10) will be slippery when used in wet or greasy conditions. Further problems may arise from the wide range of CoF within a given classification, for example R10 covers a CoF range from 0.18 to 0.34, which represents a very wide range of slip potential. Floor surfaces that are classified by the DIN 51097 standard as A (and in many instances B) will be slippery when wet.

Other tests

The instruments that have been dubbed ‘sled tests’ involve a self-powered trolley that drags itself across the floor surface. These tests do not recreate the conditions of pedestrian gait which give rise to most slip accidents. Data from such machines is unlikely to be relevant to pedestrian slipping in contaminated conditions.

The SlipAlert test[6] involves a trolley rolling down a ramp and skidding across the floor surface. The results show good agreement with the pendulum when a properly prepared Slider 96 rubber is used. A large test area is required and as the test slider travels a significant distance over the floor, it measures the average slip resistance of the area, so small areas of slippery floor may not be identified. The device does give a good visual indication of changes in slip resistance, such as from dry to wet, and can be particularly useful for staff training around cleaning.

Interpretation of manufacturers' data

Most slip resistance information provided by flooring manufacturers is produced from as-supplied products (ie ex-factory). The slipperiness of flooring materials can change significantly due to the installation process, eg due to grouting, cleaning, burnishing or polishing; and after short periods of use. Inappropriate maintenance or longer-term wear also change the slip resistance of flooring. Data quoted simply as CoF should be viewed with uncertainty, as the type of CoF test used will critically affect the validity of the data.

The test data needed to characterise a floor should relate to the floor when finished for its intended use and with any contamination present in normal use.

References and further reading

References

1 *Workplace health, safety and welfare. Workplace (Health, Safety and Welfare) Regulations 1992. Approved Code of Practice* L24 HSE Books 1992 ISBN 978 0 7176 0413 5 www.hse.gov.uk/pubns/books/L24.htm

2 BS 7976-1: 2002 *Pendulum testers. Specification* British Standards Institution 2002

BS 7976-2: 2002 *Pendulum testers. Method of operation* British Standards Institution 2002

BS 7976-3: 2002 *Pendulum testers. Method of Calibration* British Standards Institution 2002

3 *The assessment of floor slip resistance* Issue 4.0 United Kingdom Slip Resistance Group 2011

4 DIN 51097: 1992 *Testing of floor coverings; determination of the anti-slip properties; wet-loaded barefoot areas; walking method; ramp test* German National Standard 1992

5 DIN 51130: 2004 *Testing of floor coverings; determination of the anti-slip properties; workrooms and fields of activities with slip danger; walking method; ramp test* German National Standard 2004

6 *Evaluation of the Kirchberg Rolling Slider and SlipAlert Slip Resistance Meters* Available at www.hse.gov.uk/research/hsl_pdf/2006/hsl0665.pdf

Further reading

Safer surfaces to walk on, reducing the risk of slipping CIRIA C652 2006

More information about slips and trips can be found at www.hse.gov.uk/slips.

Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk/. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

British Standards can be obtained in PDF or hard copy formats from BSI: http://shop.bsigroup.com or by contacting BSI Customer Services for hard copies only Tel: 020 8996 9001 email: cservices@bsigroup.com.

This document contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

This document is available at www.hse.gov.uk/pubns/geis2.pdf.