slip sliding away

Slip resistance has to be considered when designing a polished stone floor. Dr Ian G Blanchard of the Stone & Slate Technology division of consultants STATS discusses the pendulum test used to determine slip resistance

As society becomes more litigious and safety aware, the issue of slip resistance of flooring and paving will continue to increase in importance. Consequently, a range of slip tests have been developed, based on the TRL pendulum tester described in various parts of BS 7976.

Recent publications (UKSRG[1], CIRIA[2]) offer guidance on both performance requirements and in-service management to minimise slip accident risk.

While a number of alternative test methods (Tortus, static pull test, ramp test) have been developed by various international testing agencies, the pendulum tester has been the Health & Safety Executive's (HSE's) preferred method for the UK and is now included in European Standards for internal flooring and external paving (BS EN 14231 and BS EN 1341 respectively).

Comparative studies[3] suggest that the pendulum tester correlates better with actual slip accident reports of floors in service than do the alternative methods.

Slip resistance testing, using the pendulum tester, determines the coefficient of friction between a flooring surface and pedestrian foot or vehicle wheel.

The slip resistance value (SRV) as determined by the pendulum is essentially 100 times the coefficient of friction (CoF) between the pendulum slider and the flooring material.

Generally an SRV of 36 or above (CoF 0.36) is considered safe for a non-sloping surface, being a slip level unacceptable for one in 1million pedestrians. For sloping surfaces, the required slip resistance is increase by: 100 x tangent of slope.

Therefore, if we consider the example of a three degree slope (about 1 in 20 gradient), a moderately steep slope for an internal floor, the tangent is 0.05. Consequently, the required SRV increases by five and an SRV of 41 or above would be considered acceptable.

Setting up the weighted pendulum to test the slip resistance of a floor.

The pendulum is equipped with a standard rubber slider that swings against a defined length along the surface of the test stone, the SRV being determined by the retardation of the pendulum through this contact length.

The pendulum can be fitted with rubber sliders of varying compositions to simulate different trafficking. The details of the most common of these are given in Table 1 (right).

In most cases, the test methods include both dry and water-wet surface

Table 1

Slider	Hardness IRHD	Resilience	Simulates
4S / hard rubber	94-98	22-26	normal shoed pedestrians
TRL / soft rubber	66-73	50-60	barefoot pedestrians, soft shoes (eg trainers), tyred vehicles
European (EN)	66-73	53-65	as for TRL slider

The pendulum swinging during the test. The instrument measures the distance the pendulum swings after contact with the surface being tested.

conditions, although the European standard for external paving only includes wet testing.

Generally, natural stone offers acceptably good slip resistance in clean and dry conditions with any surface finish (SRV values generally in the range 50-70). However, the performance when wet or otherwise contaminated depends on the roughness of the finished surface and on the nature of the contaminant.

When a surface is wet, slip occurs when a film of water is present between the surface of the stone and the foot or wheel trafficking over this surface.

The slip resistance of the surface is strongly related to the continuity or otherwise of this film of water and, therefore, is directly linked to the surface roughness and texture of the stone surface.

On polished stone with a smooth surface the water film has good continuity and the SRV is very low in wet conditions (typically around 10).

By comparison, flamed or hammered finishes significantly disrupt the surface film and provide frequent upstands of the stone on which grip occurs, resulting in SRVs more similar to those in dry conditions.

Consequently, these finishes are widely used externally, where it is not possible to prevent the surface getting wet, whereas polished finishes are only suitable for the routinely dry applications of some internal floors.

The surface roughness can be directly measured using an appropriate digital meter (Taylor-Hobson Surtronic Duo roughness meter) and the results of this testing can give an additional indication as to the likely wet slip resistance of the surface.

Most large-scale internal floors include a honed finish to the stone. The wet slip performance of such a finish will depend on the actual level of honing, the surface absorption and the presence and nature of any surface sealant.

Absorbent stone surfaces generally offer better slip resistance. Our testing experience suggests that an acceptable wet SRV is often attained by stone of between 120 and 240 grit honed finish*.

In many cases, the design intention is that such floors will be maintained in a dry condition by the inclusion of extensive matwells immediately inside all entrance areas.

These mats are required to dry pedestrians' feet and to prevent wind-blown rain passing through the entrance areas. Specific localised drying may also be required in the event of spillages and leaks or in cases where the capacity of the permanent matting is exceeded.

Contamination by other media can cause major differences to slip resistance. In dry conditions, dust is the most common surface contaminant and can markedly reduce the SRV of a smooth internal floor. A similar reduction to SRV has occasionally been noted when honed stone is flood grouted with an epoxy-bearing grout, causing a surface contamination.

Additionally, some settings, such as food courts and kitchens, have the potential to be contaminated with grease, which both reduces the SRV of many surfaces and causes potential staining problems for the stone.

For external paving, seasonal contamination by falling and decaying leaves, ice and dirt can significantly increase the slip risk on any surface. These contaminants tend to fill the texture of the stone surface and consequently can sometimes lead to a high slip risk even on stones with a relatively deeply textured surface.

One further consideration with natural stone is change to the slip resistance of the floor over time. Stone finishes wear either by polishing or roughening depending on:

- Levels and nature of trafficking (pedestrian and vehicular)
- Presence of surface contaminants (dust, grit)
- The nature of the stone.

The combination of these features is not always predictable, although generally harder stone types are more prone to polishing whereas granular and relatively soft stone roughens or maintains a consistent surface.

In some cases, in situ testing at regular intervals may be required to verify the acceptability of on-going slip resistance.

Overall, therefore, the slip resistance of a stone requires consideration of the surface finishes, likelihood and nature of any reasonably expected contamination and the traffic levels and consequent changes to the surface. ■

*Consider as guidance only. Project specific testing should be considered if wet slip resistance is critical.

1 The assessment of floor slip resistance – The UK Slip Resistance Group Guidelines. UKSRG Issue 3, 2005
2 Safer surfaces to walk on – Reducing the risk of slipping. CIRIA C652, 2006
3 Slip resistance and hard flooring. The Tile Association, 2003