WHERE TO NEXT WITH SLIP RESISTANCE STANDARDS?

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ABSTRACT

The annual cost of fall injuries in Australia, at approximately US$100 per head, is greater than any other single cause of accidental injury. Slip and fall prevention has thus become recognised as a national health priority area. Slip resistance standards are one of the most important research products, in that they can determine whether or not a product poses an unacceptable risk. However, the inherent limitations of the adopted slip resistance test methods have to be recognised in order to appreciate the difficulties associated with mandating certain levels of slip resistance. This paper reviews some of the legislative requirements that are driving slip resistance standards. It considers some of the options for developing future standards, with particular reference to adoption within mandatory building codes and enforceable occupational health and safety legislation.

DEFINING THE PROBLEM - SEEKING A NEW SAFETY CULTURE

In economic terms, falls cost the Australian Society more than any other cause of injury (Figure 1) [1]. While these statistics include falls due to causes other than slips and trips, for instance falls from playground equipment. However, many other slip and fall initiated injuries tend to be hidden in the statistics, for example as scald injuries, when the act of falling has caused hot liquids to be spilt. Thus while the NHMRC data may include some accidents due to causes other than slips and trips, these are probably equivalent in cost to the slip-initiated accidents that are not included. These statistics equate to an annual per capita cost of approximately US$100, where the direct morbidity costs are very high compared with most other types of accidents. The relatively low mortality costs reflect the fact that deaths due to falls occur predominantly among the elderly. It is a sobering thought that one study found that of those elderly admitted to hospital after a fall, only about 50% will survive for more than one year [2]. Falls are the leading cause of accidental death in the elderly (Figure 2) [3], where adults are more likely to be hospitalised as they age (Figure 3) [4]. The reason for this trend lies partly in the fact that people develop functional limitations as they age (Figure 4) [5], and these and other pathologies predispose people towards falls (Figure 5) [6]. General increases in instability in the elderly are small, but the effect of pathologies, many of which may be subclinical, can be critical. The concept that accumulated pathological effects may account for the increase in falling in the elderly is intrinsic to contemporary experimental methodology. A better understanding of the effect of different pathologies on postural control will allow the development of better focused intervention programs.

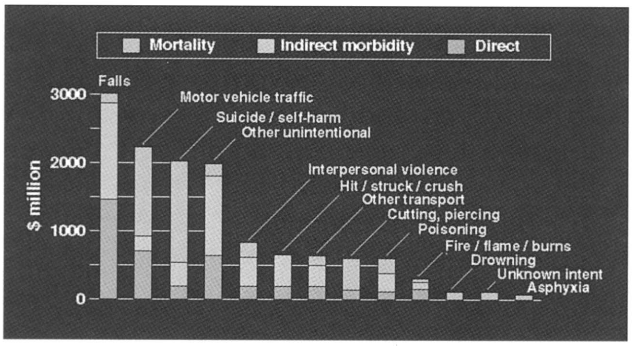

Figure 1. *Injury costs Australia 1995-96 by major cause and type of cost (adapted from [1])*

[1] *Paradigm Shift - Injury: from problem to solution - New research directions,* Strategic Research Development Committee of the National Health and Medical Research Council, AGPS, Canberra, 1999.

[2] Overstall, P.W. *Falls in elderly: Epidemiology, aetiology and management.* In Isaacs, B., (ed), Recent Advances in Geriatric Medicine. New York, NY: Churchill Livingstone (1978).

[3] Anon, *Australian Injury Prevention Bulletin,* Issue 17, 1998.

[4] Watson, W.L. and Ozanne-Smith, J., *The Cost of Injury to Victoria,* Monash University Accident Research Centre Report 124, December 1997.

[5] Vanderheiden, G.C., *Thirty Something (Million): Should They Be Exceptions?,* Trace Center, 1998, http://trace.wisc.edu/docs/30_some/30_some.htm.

[6] Shupert, C.L. and Horak, F.B., *Adaptation of postural control in normal and pathologic aging: Implications for fall prevention programs.*

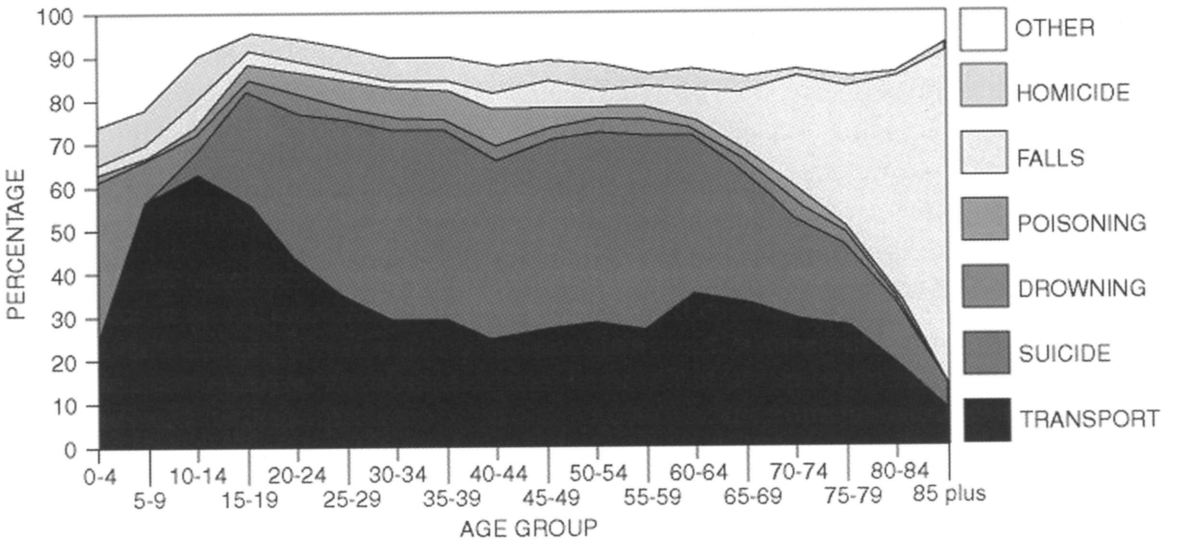

Figure 2. Proportions of major types of injury deaths by age-group, Australia 1995 (adapted from [3])

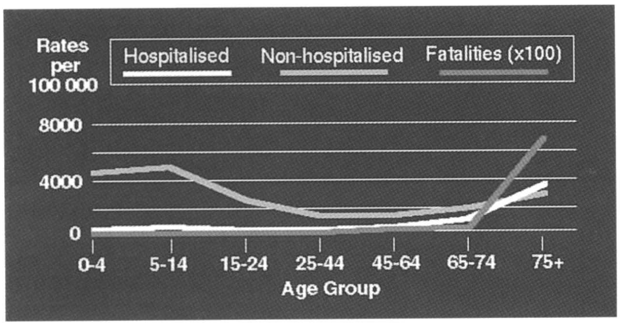

Figure 3. Fall injuries by age and severity, Victoria, 1993-94 (adapted from [4])

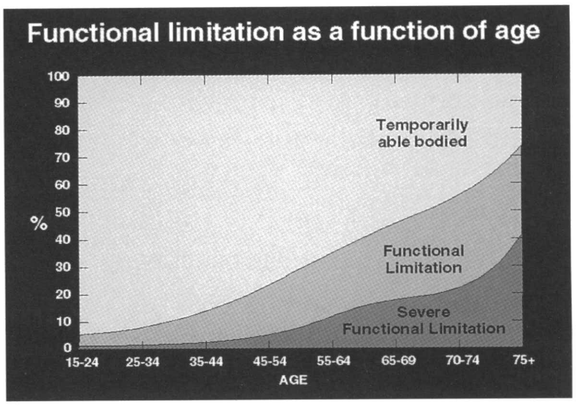

Figure 4. Functional limitation as a function of age (adapted from [5])

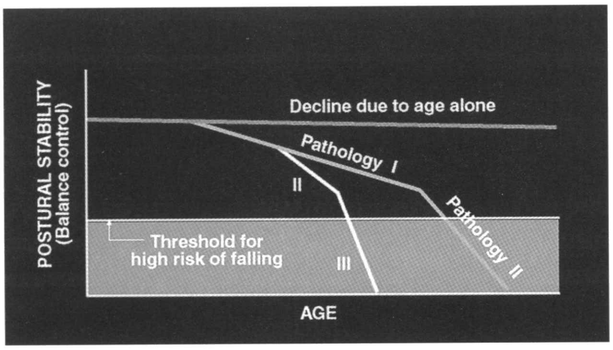

Figure 5. Schematic representation of a model for the effect of multiple pathologies on postural stability as a function of age (adapted from [6])

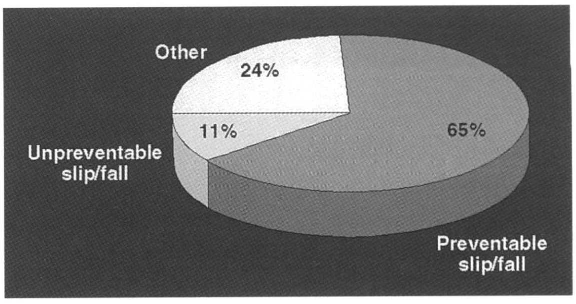

Figure 6. Public liability incidents, analysis of cause (adapted from [7])

[7] ANDERSON, C.R., *Public liability insurance costs,* Building Owner & Manager, Feb., p. 76, 1990.

Public liability claims show that at least 86% of falls have extrinsic causes that are preventable (Figure 6). While a large number of falls occur inside the home, or outside the home but within the property, the risks that we face are similar whether at home, at work or in public areas. It is thus reasonable to assume that approximately 85% of all falls have extrinsic causes that are preventable. The elimination of the most hazardous situations would seem to offer a tremendous cost benefit. Despite this, little research has been undertaken into comprehensive intervention strategies designed to reduce the extrinsic causes of slips and trips.

Besides the elderly, there are some occupations that have particularly high risks of falling. For instance, the catering industry has a very high rate of slip-related injuries, where 90% of the slips occur on wet floors. Structural steel workers are particularly vulnerable to falls from heights if they are not securely harnessed. In such occupations, selection and appropriate maintenance of footwear can become critical. There is an urgent need to develop slip resistance standards for footwear.

Slips can be wholly or partly due to several causes other than flooring materials that were inherently slippery when new, for example poor lighting and incorrect cleaning practices. While there is no single simple solution, this should not impede the implementation of a wide range of interventions. Intervention programs have sought to address both the intrinsic and extrinsic causes, particularly focusing on those most at risk - the elderly and those in specific occupations. Intrinsic causes include gait instability, muscle weakness, and visual and sensory impairment. Typical intervention strategies focus upon exercise programs to improve fitness, gait and balance clinics, and advice about medication and how behavioural modifications can reduce the risk of falling. Modification of the home environment is a complementary strategy. Typically trained safety advisers might conduct free home audits and offer subsidised simple modifications, such as resurfacing slippery floors, providing grab-rails at key locations, and improving illumination. Such programs may have the additional benefit of educating people about the risks with a behavioural modification domino effect.

Although further intervention programs with the elderly will probably yield incremental benefits, this most susceptible group is a subset of the general population and is exposed to the same extrinsic risks when they venture outside their safety-improved homes. Reducing the level of risk in public areas will benefit everyone, but particularly those who are less able bodied. What specific requirements or additional demands do the elderly and the disabled place upon floor surfaces? Unfortunately this is poorly known, at least by those with an interest in pedestrian slip resistance. While there have been several gait studies of various mobility impaired groups, where the ground reaction forces have been measured, these have rarely been published in terms of coefficient of friction. A new paradigm is obviously required.

The extrinsic causes relate more to environmental hazards - the selection and maintenance of floor surfaces; spills, drips, leaks or condensation; cables or objects left in traffic areas; inappropriate footwear; poor lighting; etc. However, obscured vision due to carrying large loads can also cause accidents. In an occupational context, this leads to the need for risk analysis and the implementation of appropriate training.

SPECTRE OF INCREASING REGULATION

Slip resistance regulation has traditionally been covered in two distinctly separate areas: building regulations and occupational health and safety (OHS) requirements. In Australia, these were originally State based, and there were also local Government responsibilities with regards to footpaths and other public areas. However, the recent trend towards increasing regulation has largely been driven by the need to provide equitable and dignified access for people with disabilities. Unfortunately, authorities have tended to mandate slip resistance using abstract relatively non-enforceable terms such as non-slip and slip-resistant. The other driver for higher slip resistance has been self-protection, where people have been feared being sued.

The public expects that they can walk with safety, and that the legal system will provide them with redress and compensation where a building owner, manager, architect or some other person has been negligent. They also expect that product literature, whether local or produced overseas, will enable them to make an informed choice. Given the increasing proportion of elderly persons within most countries, and thus an increasing level of functional impairment, access has become recognised as an important design issue. Very good design can be enabling and motivating for those otherwise denied access through physical barriers and poor design. By contrast, bad design can seriously inconvenience, be cost inefficient and even hazardous. There has been a growing international trend towards a more humane architecture known as universal or adaptable design. AS 4299:1995, *Adaptable housing*, presents the objectives and principles of adaptable housing. Adaptable design involves a move away from designing special accommodation for different community groups with different needs. Such design avoids the personal and economic costs that accompany social dislocation. Lifetime homes have design features that add built-in flexibility that make homes easy to adapt as peoples' lives change. In Britain, all housing built after October 1999 must comply with the Part M (access and facilities for disabled) requirements of the Building Regulations.

AUSTRALIAN BUILDING REGULATIONS

The Building Code of Australia (BCA) is a statement of the minimum technical requirements for the design and construction of buildings. The Australian Building Codes Board (ABCB) produces the BCA in conjunction with, and on behalf of the State and Commonwealth Governments, who each have statutory responsibility for building regulation within their own jurisdiction. Each Government adopts the BCA as the technical building code, so it is uniform across Australia. The BCA, by means of State building legislation, requires most public buildings to have features to enable access and use by people with disabilities, and specifies which classes of buildings, which areas, and how many facilities, should be accessible. It calls up Australian Standards such as AS 1428.1, *Design for access and mobility: General requirements for access - Buildings*, as means of compliance. From 1996, the Disability Discrimination Act (DDA) was viewed as having precedence over other legislation, and a review of the BCA was commenced, with the aim of harmonising BCA requirements with DDA expectations [8]. The BCA has a limited scope - that of requirements for new public buildings and works. The DDA definition of premises extends to the whole built environment, i.e. new and proposed buildings and existing buildings, including heritage buildings, pathways, car parking spaces, parks and transport systems.

The ABCB is aiming to harmonise the BCA requirements with the expectations of the DDA in relation to new buildings. A major cause of delay in this harmonisation process has been the lack of empirical research on the needs of people with disabilities, and options for meeting these needs. There is also some difficulty in reconciling the difference between the BCA that establishes minimum requirements and the DDA that seeks to establish the optimum solutions. This is partly reflected in AS 1428.2:1992, *Design for access and mobility: Enhanced and additional requirements - Buildings and facilities.* This Standard gives enhanced requirements for access for users who wish to provide a greater level of accessibility than the minimum requirements of AS 1428.1.

The Disability Discrimination Act 1992 (DDA) makes it unlawful to discriminate against any person on the grounds of disability in a broad range of areas, including access to premises. At any one time an estimated 25 to 30% of the Australian population have a disability of one kind or another, including 19% with permanent disability [9]. 84% of people aged 85 and over have a disability. Provision of equitable access requires that all parts of premises, to which the public and employees have a right of access, must be connected by a network of continuous paths of travel.

Disability discrimination legislation usually applies to owners and operators of buildings, and to service providers operating within buildings. The DDA is complaint based, allowing complaints to be lodged in the event of alleged discrimination against people with disabilities. This is usually after construction and so could result in more costly rectification than if done during construction. The DDA includes 'unjustifiable hardship' as a defence in the event of a complaint. It also includes a provision for action plans as a means of expressing a commitment to a program for upgrading the accessibility of an existing building, but does not provide for their approval or endorsement. The DDA encourages building owners and facility managers to develop and lodge action plans with the Human Rights and Equal Opportunity Commission (HREOC). Action plans assist owners and operators to eliminate discrimination in an

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[8] NATIONAL ACCESS WORKING GROUP, *Accessible Design in Australia: A National Approach for an Integrated Future*, October 1999, http://www.ot.cchs.usyd.edu.au /NAWG/DiscussionPaper.html.

[9] AUSTRALIAN BUREAU OF STATISTICS, *Survey of Disability, Ageing and Carers.* Commonwealth Government Printing Office.

active way; reduce the likelihood of complaints being made; increase the likelihood of being able to successfully defend complaints; increase the likelihood of avoiding costly litigation; and allow for planned and managed change in business or services.

Building owners and building control authorities need the certainty of knowing that appropriate decisions taken in good faith prior to construction, including compliance with the BCA, are unlikely to be overturned by a later complaint under the DDA. There has thus been considerable discussion about the establishment of a process that would ensure, as far as possible, that the application of the BCA to new and existing buildings delivers access for people with disabilities in a way that is consistent with the DDA.

A recent Human Rights Amendment Bill now allows HREOC to develop a DDA Standard on 'access to or the use of any premises, by persons with a disability, that the public or a section of the public is entitled or allowed to enter or use (whether for payment or not.)' The AS 1428 suite of Standards is being reviewed with the aim that they might be capable of becoming DDA Access Standards. The adaptable housing and parking Standards are being reviewed, and new Standards are being written covering the Outdoors; Furniture, Fittings & Equipment; and Design for Aged Persons.

AUSTRALIAN OHS REGULATIONS

Australian OHS regulations are still State based. Typically, they require employers to identify any foreseeable hazard that may arise from the physical working environment, including the potential for people falling. Employers must assess the risk of any hazard identified with respect to the health and safety of their employees and any other person at the place of work. When assessing risks, the employer must evaluate the likelihood of an injury occurring and its likely severity; review available health and safety data relevant to a particular hazard; and identify the actions necessary to eliminate or minimise the risk. They must take into account the layout and condition of the working environment; the capability, skill, experience and age of people ordinarily undertaking work; the systems of work being used; and reasonably foreseeable abnormal conditions. Employers must review risk assessments and control risks. If it is not reasonably practicable to eliminate the risk, the employer must minimise the risk to the fullest extent possible. Any such minimisation of the risk must, as far as is reasonably practicable, be achieved by means other than the provision of personal protective equipment. An employer must ensure that all measures (including procedures and equipment) that are adopted to eliminate or minimise risks to health and safety are properly used and maintained. Employers must also ensure that each new employee receives induction training on relevant health and safety matters. Employers must provide any supervision necessary to ensure the health and safety of employees and any other person at the work place. In circumstances where it is not possible to eliminate a risk or to minimise the risk by means other than the adoption of personal protective equipment, the employer must ensure that the personal protective equipment is appropriate for the person being protected and minimises the risk for that person. The employer must also ensure that the personal protective equipment is properly maintained and is repaired or replaced as frequently as is necessary to minimise the risk for the person being protected. The owners of workplaces have similar general duties with respect to identifying hazards and assessing and controlling risks. They must also provide all available information to other persons, such as employers, to enable them to fulfil their OHS responsibilities. The owner of a place of work must ensure that safe access is provided to all parts of a building or structure that comprise a place of work to which a person may require access and from which the person may fall, and floors are designed to be safe without risks of slips or trips, with adequate drainage (if necessary) and appropriate floor coverings (if necessary). An employer must ensure that floors and surfaces are constructed and maintained to minimise the possibility of slips and trips, and persons are able to move safely around the workplace. An employer must ensure that lighting is provided that is adequate to allow employees to work safely; does not create excessive glare or reflection; is adequate to allow persons who are not employees to move safely within the workplace; and facilitates safe access to and egress from the workplace, including emergency exits.

HOW HAVE THESE REGULATORY REQUIREMENTS BEEN EXPRESSED?

While there are mandatory OHS requirements, the regulations pertaining to floors have been typically expressed as 'All floors (or their coverings) must have an even and unbroken slip-resistant surface which is free from holes, indentations, projections or other obstructions likely to cause a person to trip or stumble'.

There has been more specific guidance, such as the following given in AS 1470:1986, Health and safety at work - *principles and practices*, but this standard only sets out recommendations. 'Precautions necessary to prevent falls and to minimise their effects entail constant attention to housekeeping'. 'Surfaces on which persons stand or walk should be sufficiently even to afford a safe foothold, with consideration being given to the inclusion of permanent non-slip surfaces. The surfaces should, where practicable, be free from holes, projections and obstructions which may create a risk of stumbling, and should not be allowed to become slippery through wear, spillage of water, oil, or other material. Where slipping is especially dangerous, adequate handholds and guard railings should be provided. Where a number of different materials are used on walking surfaces, rapid and significant changes in the coefficient of friction should be avoided. The influence of liquids on walking surfaces should be taken into account. In some instances, the performance or characteristics of the shoes must be enquired into and appropriate choices made'.

The BCA has also made great use of the terms non-slip and slip-resistant, but has now been modified to also require all aspects of most buildings to comply with AS 1428.1:1998. This requires that 'All continuous accessible paths of travel shall have a slip-resistant surface'. However, AS 1428.1 still fails to provide an adequate definition of slip-resistant or any reference to an acceptable test method.

What is slip-resistant or non-slip? The commentary on floor surfaces in AS 1428.1 Supplement 1: 1990 began 'The practical testing and specifying of a floor surface to ensure slip resistance is complicated. There is no general purpose reliable testing equipment available at the present time. Test results vary because of the significance of the condition of the floor surface and the condition and characteristics of contact materials used on soles and heels of footwear, and on contact surfaces of mobility aids. Some synthetic sole materials, for example, provide a good grip on wet paving stone slabs, while some other synthetic soles and some rubber soles provide virtually no slip resistance on the same material, and under the same conditions'. Different slip resistance test methods can also give contradictory indications.

Authorities often prefer to mandate using abstract terms such as no-slip and slip-resistant, rather than specifying requirements that might be subsequently found to be inappropriate. This is probably why it was left to the non-mandatory comment in AS 1428.1 Supplement 1: 1990 to indicate that it was desirable that the static coefficient of friction of floors, when wet or dry, should be at least 0.40.

AS 3661.1:1993, *Slip resistance of pedestrian surfaces - Requirements*, had compliance requirements of 0.4 for the wet and dry dynamic coefficient of friction. It was called up in the 1996 BCA, but only in the Australian Capital Territory variations. It has subsequently been removed because it was found that compliance did not automatically provide a floor that was sufficiently slip-resistant to prevent all accidents. In reality, the limitations of the chosen test methods were unable to always permit adequate discrimination between those products that were marginally slippery and others that were more slip-resistant. However, the same criticism may be made of most other slip resistance test methods. AS 3661.1 has been called up in a number of other Standards including AS 4226:1994, *Guidelines for safe housing design*. This sensibly defines slip resistant as 'able to substantially reduce or prevent the risk of a person slipping. It is used generally to refer to those textured flooring materials that perform well in preventing slipping in both wet and dry conditions'.

NEW AUSTRALIAN SLIP RESISTANCE STANDARDS

The perceived problems with AS 3661.1 is leading to the development of a new suite of slip resistance standards. Standards Australia handbook HB 197:1999, *An introductory guide to the slip resistance of pedestrian surface materials*, provides guidelines for the selection of slip-resistant pedestrian surfaces classified in accordance with AS/NZS 4586: 1999, *Slip resistance classification of new pedestrian surface materials*. As the title suggests, these publications deal not only with ceramic tiles, but also with other products such as stone, terrazzo, vinyl, rubber and concrete pedestrian surfaces. This multi-product approach follows that taken by the Germans with the DIN 51130 and DIN 51097 ramp tests. There now appears to be a move in Europe towards integrating pedestrian slip resistance standards.

AS 4586 has classified wet pendulum slip resistance test results based on the 'contribution of the floor surface to the risk of slipping when wet'. While this classification system is notionally based on a universal slip resistance requirement (a wet coefficient of friction of 0.4), it serves to emphasise that the floor is but one element of the potential problem. Although the slip resistance potential of footwear is obviously important, there are currently no Australian or ISO standards for determining the slip resistance of footwear. Thus there is no rating system to advise people which are the safer shoes to wear. CSIRO is thus preparing a draft Australian Standard - a test method for the determination of slip resistance of safety, protective and occupational footwear for professional use.

As Table 1 shows, AS 4586 includes four separate test methods (dry floor friction tester, wet pendulum, wet barefoot ramp test, and oil-wet ramp test). The existing AS 3661.1 test methods, the pendulum and the floor friction tester are retained, with adoption of the German ramp test methods, particularly for the assessment of heavily profiled surfaces. The ramp tests allow more relevant measurement of wet barefoot slip resistance and of slip resistance in oily industrial situations. Each test method can be used to classify a product, using its own unique classification scheme. Although four test methods have been proposed for ISO 10545-17, Ceramic tiles - slip resistance, only the DIN 51130 ramp test has a comprehensive classification system.

Test method	DIS ISO 10545.17		Current requirements in some other countries	AS/NZS 4586	
	Dry	Wet		Dry	Wet
Static	x	x	USA - ASTM C 1028	-	-
Floor Friction Tester	x	x	Italy	x	-
Pendulum, Four S rubber	x	x	UK draft	-	x
Pendulum, TRRL rubber	-	-	UK, USA - vehicular	-	x
Ramp, DIN 51130	-	Oil	Germany	-	Oil
Ramp, DIN 51097	-	-	Germany, France	-	Water

Table 1. *Comparison of proposed standards with respect to current international usage*

HB 197 recommends minimum floor surface classifications for a variety of locations, and includes some commentary on the AS 4586 slip resistance test methods. It also provides information on some additional requirements for sloping surfaces. Although HB 197 reproduces the German requirements, it also includes a dual (Pendulum and ramp) classification Table for specific locations where some of the German requirements have been increased. This reflects Australian experience that the R9 classification is too broad. There have been rumours that the Germans might abandon the R9 classification, but it would be more sensible to introduce a new class R8 (perhaps at 6 or 7 degrees) that would distinguish between noticeably slippery and extremely slippery products. Perhaps this will be achieved when the whole test method is overhauled, since the specified boots are no longer available and the calibration boards are prohibitively priced. Another option would be to adopt a water-wet ramp test where the shoes have a smooth rubber sole that can be resurfaced. Rapra Technology Limited has developed such a test, but it does not have any calibration boards or correction values (which would seem essential for reproducible results).

AS 4586 describes the pendulum classes in terms of the relative contribution of the floor surface to the risk of slipping when wet. This deliberately recognises that the pedestrian surface material is only one of several factors that contribute to the risk of slipping. However, such a description is fundamentally flawed since it essentially relies upon an assumption that there is a universal minimum slip resistance threshold value (in this case a wet Pendulum coefficient of friction of 0.4) that can always differentiate between what is safe and what is not. Different operational environments dictate that an industrial kitchen requires a more slip resistant floor than a domestic kitchen.

HB 197 contains a table of equivalent slip resistance terminology (Table 2) where a non-slip floor is described as 'safe for normal stride and pace and moderate attention'. However, one cannot automatically relate this to a coefficient of friction range, since any test result is dependent on the test method used, and the safety requirements are dependent on the anticipated exposure and traffic conditions. Nevertheless, this philosophical approach offers a new paradigm that has interesting implications for forensic investigations of slip and fall accidents.

Equivalent slip resistance terminology				**Coefficient of friction range**
Absolutely not slippery	Unquestionably safe	Safe for widest range of abnormal stride and pace	Slip highly improbable	***Coarse bitumen***
Noticeably less slippery	Adequately safe	Safe for rapid stride and pace	Non-slip at very rapid pace	**This will depend on the test method used as well as the anticipated exposure and traffic requirements**
Detectably less slippery	Acceptably safe	Safe for hurried stride and pace and minimal attention	Non-slip at rapid pace	
Non-slip	Safe	Safe for normal stride and pace and moderate attention	Non-slip at involuntary pace	Possibly 0.35 to 0.46 when tested wet according to AS/NZS 3661.1
Detectably slippery	Marginally safe	Safe for normal stride, pace and attention	Non-slip with reasonable care	**This will depend on the test method used as well as the anticipated exposure and traffic requirements**
Noticeably slippery	Marginally unsafe	Safe for reduced stride and cautious pace	Non-slip with caution	
Extremely slippery	Unquestionably unsafe	Safe for short stride and extreme care	Slip highly probable without extreme caution	***Wet ice***

NOTE: Adapted from ASTM D21.06 questionnaire reprinted in *Ergonomics*, 1985, 28(7), 1062.

Table 2. *How does one equate non-slip with a coefficient of friction?*

Although SAA HB 197 suggests some minimum requirements for specific locations, such as shopping centre food courts, these have been poorly researched and are unlikely to be incorporated in the Building Code of Australia until they can be demonstrated to be reasonable. The ABCB will evaluate the public response to the HB 197 recommendations prior to considering their adoption in the BCA. Economic impact studies will probably also need to be conducted before any recommendations can be adopted.

AS 3661.1 will be withdrawn when the next Australian Standard in the slip resistance series, *Slip resistance measurement of existing surfaces,* is published. This will again specify the use of the wet Pendulum and the dry Floor Friction Tester. This standard will be used in two principal scenarios: where routine safety audits are made, and as a starting point for accident investigations. Given the diverse nature of these operations, this standard is likely to again include the clause 'The test surface shall reflect the nature and purpose of the testing'. It is important to note that the standard will not preclude other measurements being made, with either other shoe materials, contaminants or devices. The standard is intended to provide a consistent means of obtaining common measurements of floor surfaces. This effectively determines a common language that all should be able to readily comprehend. AS/NZS 3661.2:1994, *Slip resistance of pedestrian surfaces: Guide to the reduction of slip hazards,* will be withdrawn when a more comprehensive Slip Resistance Handbook is published in mid-2000. This Handbook will also supersede HB 197.

While AS 4586 might be regarded as an incremental advance, it is important to recognise its general limitations and the further studies that are required, for instance the applicability of the results from the various test methods to other soling materials, bare feet, socks, specific sole tread designs, and contaminants other than water, particularly dusts and various solid materials. The interpretation of many results would probably benefit from expert analysis.

ESTABLISHING NEW PARADIGMS FOR PEDESTRIAN SAFETY TO PREVENT SLIP AND FALL INJURIES

CSIRO BCE [10] has identified a wide range of issues including the need to:

- develop process control equipment to ensure products provide consistent slip resistance
- ensure the use of the most reliable means of assessing the slip resistance of pedestrian surfaces
- confirm the most appropriate design solutions for the BCA and specific OHS situations
- develop performance indicators to determine the relative safety of an existing floor
- develop an integrated design guide for flooring
- ensure cleaning systems are planned at the design stage
- develop risk assessment based flooring performance specifications
- determine the slip resistance required by various mobility impaired groups
- develop a simple audit procedure for health workers to assess the relative safety of floors

[10] BOWMAN, R., *What must we do to reduce pedestrian slips and falls?* 3rd National Conference on Injury Prevention and Control, 9-12 May 1999, Brisbane.

- develop a footwear slip resistance standard
- quickly formulate an appropriate strategy to implement research and initiate further intervention measures
- provide incentives for companies to undertake proactive, effective prevention measures

CSIRO held a slip resistance workshop in June 1999 where a wide range of stakeholders participated. This confirmed not only the need for the above work to be conducted, but also raised a number of educational requirements and training issues. For example, once a footwear slip resistance standard is developed, there should be a concerted campaign to persuade footwear manufacturers to provide the relevant information, and an educational campaign to assist consumers to purchase appropriate footwear, particularly those in high falls risk occupations. This would extend to the provision of a wide range of useful information about footwear maintenance issues. CSIRO will also be advising Standards Australia Committee ME/64, Access for People with Disabilities, how they might improve the guidance given in AS 1428.1 as to what constitutes a slip-resistant surface.

It is likely that paradigms for the new millennium will be based on:

- Rejection of a universal coefficient of friction threshold (even if this is intrinsic to the Americans with Disabilities Act Accessibility Guidelines [ADAAG]). Although ADAAG requires that floor surfaces of accessible routes be slip-resistant, no standards or methods of measurement are specified. However, an appendix contains advisory recommendations for slip resistance values: a static coefficient of friction of 0.6 for accessible routes and 0.8 for ramps.
- Recognition of limitations of various test methods, and thus where they can be safely used
- Recognition of the needs of functionally impaired groups and how to tailor intervention programs
- Adoption of footwear standards and increasingly sophisticated or specific ratings of footwear slip resistance
- Recognition of critical role of cleaning/ maintenance and adoption of new criteria and methodologies

IMPLICATIONS FOR SLIP RESISTANCE TEST METHODS

While ISO 10545-17, *Ceramic tiles: Determination of coefficient of friction*, has still to be published, it is likely to adopt four test methods (Table 1), even if a lack of the specified shoes will prevent any new laboratory from conducting the ramp test. This prolonged delay largely reflects the potential impact of such a Standard on existing national regulations, although some countries may have recognised some potential limitations and adopted a different position in line with a proposed national standard. Such national interests would seem to offer little latitude for future development of this ISO standard, which is reactive rather than proactive, where the ISO standardisation process is slow and poorly geared to react to change at the national level. However, given the influence of national standards on international trade, where one must comply as a condition of doing business, a more proactive situation is necessary. Effective development of slip resistance test methods is likely to require greater international collaboration, less partisan sectoral influence, and a greater national willingness to recognise and adopt progressive change.

Further test methods are being developed and will continue to be developed. The operational procedures for some apparatus are now covered by standards, for example ASTM F 1678 and ASTM F 1679. While it is possible that these test methods might give a more accurate indication of slip resistance of ceramic tiles than ASTM C 1028, or its DIS ISO 10545-17 derivative, they are unlikely to be willingly adopted by the tile industry for political reasons. It is important that the acceptance of any method for a specific application should be based on subjective experience. For example, it was proposed that the VIT be used to measure the slip resistance of steel products. However, research showed that the VIT could not correctly rank wet steel and ice [11]. Any test method must be rigorously independently assessed before it is applied to a highly specific context.

There appears to be a growing international acceptance of the paradigm that one must recognise the limitations of any test method before determining whether it can be applied to a specific situation. This requires parallel studies of subjective experience, as well as more sophisticated biomechanical studies. This approach should enable the development of acceptable low cost devices that health care workers could use when assessing slip resistance in outpatients' homes. However, they will still need to be taught how to evaluate whether a potential problem is with the floor surface that was laid, or with the manner in which it has been maintained. A similar device might be used for non-specialist access audits, but specialists may need to use a number of devices or techniques. This is particularly likely to be the case in an OHS context if the floor surface is heavily structured.

Given that the purpose of a standard is to fulfil a consumer need, who are the consumers of slip resistance standards, and are their needs being satisfied? The consumers would include but not be limited to tile manufacturers, merchants, architects, building owners, facility managers, employees, cleaning contractors, cleaning product manufacturers, insurers, the general public, various disabled groups, access auditors, forensic scientists, and test houses. AS 4586 should satisfy manufacturers as it enables them to demonstrate compliance with the slip resistance classifications. HB 197 provides guidance as to how these classifications might be interpreted, but it also indicates that some of the recommendations for specific locations may be lenient while others may be onerous. Furthermore, it advises that there are other design considerations. These include allowing for the amount and type of expected traffic (vehicles, trolleys, people hurrying, elderly, disabled people with or without walking aids, and children); the product characteristics (wear resistance and cleanability) and the consequences of exposure to the types of contaminants that might be anticipated; environmental design factors (visibility issues and contamination minimisation); management policy and maintenance practices (type of cleaning equipment, frequency and effectiveness of cleaning); compliance with

[11] KYED, P.J., *Human traction versus ASTM F 1679-96 measurements: A comparison of ice and wet ACRYZINC sheet,* Report to OSHA/SENRAC Steel Coalition, March 10 1999.

occupational, health and safety requirements; special provisions for slip hazards (guards and handrails); and alternative information sources (use of contrasting colours and warning signs). Although the use of a classification system assists architects to select appropriate products, it does not relieve them of the need to verify the appropriateness of their choice. This may extend to a consideration as to whether the slip resistance data has been derived from an appropriate test method. For instance, the ramp test methods are likely to give a more relevant indication for wet barefoot and industrial locations. Architects may also have some difficulty in analysing technical product literature to assess which of two products is more likely to retain its appearance and performance with time and wear.

Access auditors, insurers and cleaning contractors are concerned about the available level of traction at any given time. Where an accident has occurred, selection and preparation of the test surfaces becomes a more critical issue. Some inspections are not conducted until several weeks or even years after the accident. Thus assumptions have to be made about the condition of the floor surface at the time of the accident. While forensic investigators will often make a series of measurements on the floor as found and after various cleaning regimes, it is difficult to quantify relative cleanliness. The type and number of measurements that a forensic investigator might make are likely to depend on the specific circumstances. Surface roughness measurements provide an additional indication of slip resistance potential and are easily made. Planarity measurements may be appropriate to ascertain whether there may have been a conformity problem with the pendulum slider. Supplementary laboratory ramp tests may be appropriate for some products. Laboratory testing of footwear, under biomechanically relevant conditions, may also be appropriate. The relationship between slip resistance test results obtained using Four S rubber and other footwear soling materials is largely unknown. While some people advocate that flooring products should be tested with several soling materials, this is generally impractical. It is likely that steel will indicate that all pedestrian surfaces are dangerous, while thermoplastic rubbers will tend to indicate that most are quite safe. However, the relative order of ranking of a range of floor surfaces by a range of soling materials is likely to be similar. The use of a single surrogate material is intended to provide the optimum discrimination without grossly inflating the cost of testing. Even if a relationship was established between Four S rubber and other soling materials, it would not necessarily provide an indication of the likelihood of people slipping when wearing shoes with a specific type of soling. If one wanted to be exhaustive, one should also consider the influence of the sole tread pattern, although the lack of tread on sliders, perhaps simulating loss of tread on shoes, may represent the worst case scenario for wet slip resistance.

Corporate cleaning 'standards' have largely been dominated by a perception of what is clean, e.g. sparkling floors, rather than the provision or maintenance of adequate slip resistance. Again, new paradigms are required, both with respect to maintenance and to predicting the durability of floor finishes when put into specific service situations.

One of the pressing challenges for managers of heritage sites is how to introduce equitable and dignified access for all people, when potential solutions, such as a ramp, might compromise the very heritage values that make the place significant. Access solutions will be unique to each historic building. Consequently, standardised design makes little sense. However, adopting a process based on an understanding of the principles of access will assist designers to achieve effective solutions. There is usually more than one way to solve a problem, and this often applies to slip resistance. Options should be fully explored and the impact of each assessed before a final solution is selected.

IN SUMMARY

In Australia, approximately 85% of falls are preventable. Prevention of some of the extrinsic causes should result in a significant reduction in the A$3 billion annual cost of fall injuries. Many commercial buildings are still not 'fit for purpose' because the selected floor surface either offers too little slip resistance, or pedestrian safety is jeopardised by some other design input. Furthermore, the performance of many floors is often compromised by unsuitable cleaning practices, given the lack of routine slip resistance assessment in most buildings. Although the largest Australian settlement for a single slip and fall accident (believed to be $2.75 million) may be small compared to some American cases, pedestrian safety does not appear to have been considered as a component in life cycle costing studies. While there is an international trend towards requiring all accessible paths of travel to have a slip-resistant surface, there are no specified means of demonstrating compliance. Since there is a growing demand for safer pedestrian surfaces, particularly among the elderly and the disabled, regulatory authorities will soon need to evaluate the available options and the economic impact of mandating minimum levels of slip resistance. A major impediment to improving the pedestrian safety performance of commercial buildings is the lack of integrated performance indicators and a general inability to assess slip resistance in situ.

Since the elderly tend to become more disabled as they grow older, designers should recognise that disability is a normal condition of life. There is a growing awareness of the need for safe design, and this is likely to be enforced by more specific performance based regulations. There is significant appreciation of the high incidence of litigation and the potential cost of failing to provide safe flooring, and thus an increasing awareness of the complementary need for satisfactory maintenance. All these drivers demand an increasing degree of surety. However, there is a continuing doubt as to the level of surety that can be provided since slip and fall accidents generally have multifactorial causes. A large amount of multidisciplinary research is required and this should preferably be conducted with significant international collaboration. Where definitive answers are required in specific cases, there are existing organisations capable of conducting highly focused research studies.