Drainable pavements for improved walkability

Best practice for surface stormwater management in public spaces

ACO

"Poor drainage specification, or a lack of specification, opens the door for the contractor to make decisions that are not in the best interest of other stakeholders. Those decisions will likely be based on short-term objectives, for instance, the purchase price of drains. But with proper planning and discussion, the designer can save the asset owner money and produce a result that is functional, sustainable, safer for pedestrians and more aesthetically pleasing."

John Sordo
Manager – Marketing & Product Management, ACO Pty Ltd

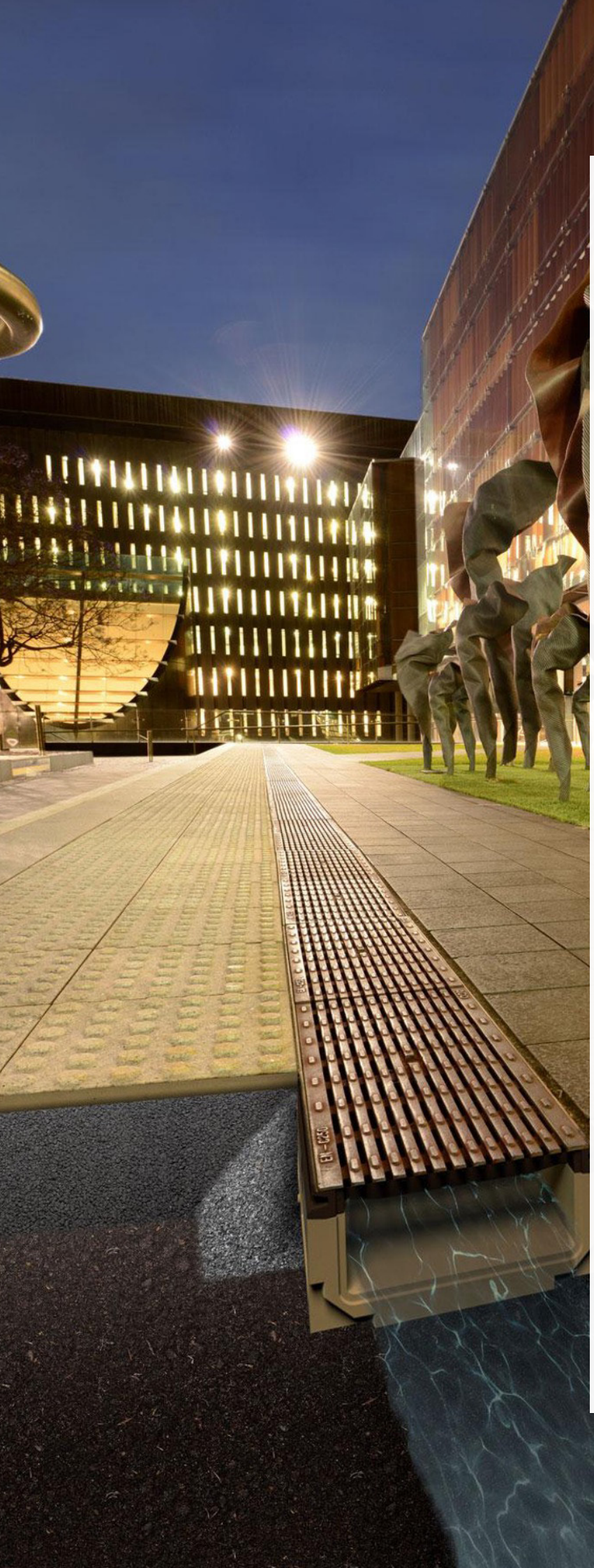
Cities are increasingly prioritising pedestrian thoroughfares and foot traffic over roads and motor vehicles. That's because walking cities give rise to a host of benefits — from health to economic to social — that can significantly improve urban landscapes and the lives of the people living in them.

A world-renowned report from global engineering firm Arup called *Cities Alive: Towards a Walking World*, highlights how the benefits of having walkable public spaces has put walkability front of mind for decision-makers and designers in the built environment.

"We know that a walkable city is a better city and that the more we walk the better the city in every respect," reads the report.

"It is the lowest carbon, least polluting, cheapest and most reliable form of transport, and is also a great social leveler. Having people walking through urban spaces makes the spaces safer for others and, best of all, it makes people happy."

A study from the George Washington School of Business, called *Foot traffic ahead: Ranking Walkable Urbanism in America's Largest Metros*, found that areas of greater walkability tended to have a greater number of people with higher education levels compared to other areas. Those areas also boasted a "one-third higher GDP per capita in high-ranking cities".



Unfortunately litigation is an unintended by-product of walkable cities. Annual bodily injury claims across Australia can total more than $400 million.* Liability for slips, trips and falls can extend from business and property owners to councils, architects and engineers.**

As a result, there are often claims across Australia for bodily injury. The *average claim* can settle anywhere up to $100,000 with the potential to settle for more.

Many of these claims could have been avoided if surface runoff was properly managed to protect people and property, and if more thought had gone into the pavement surface and it's elements.

Designs that get the walking surface right for both wet and dry weather include the use of flat and level pavements comprising grates and covers that facilitate the safe mobility of pedestrians. Additionally, these walkable surfaces and their elements not only physically interact but can visually interact with the environment. The best designs offer enormous benefits to all stakeholders, from councils, private asset owners to the users themselves.

In this paper, we provide a guide to the five most vital considerations when designing pavements with good surface water management:

1. Flat and level surfaces
2. Slot criteria
3. Slip resistance
4. Durability and strength
5. Aesthetics

* Kundan Misra, et. al., "Review of Claims Trends for Liability Insurance in Australia"

**Indigo Mist Pty Ltd v Palmer [2012] NSWCA 239

1. Flat surfaces offer numerous benefits

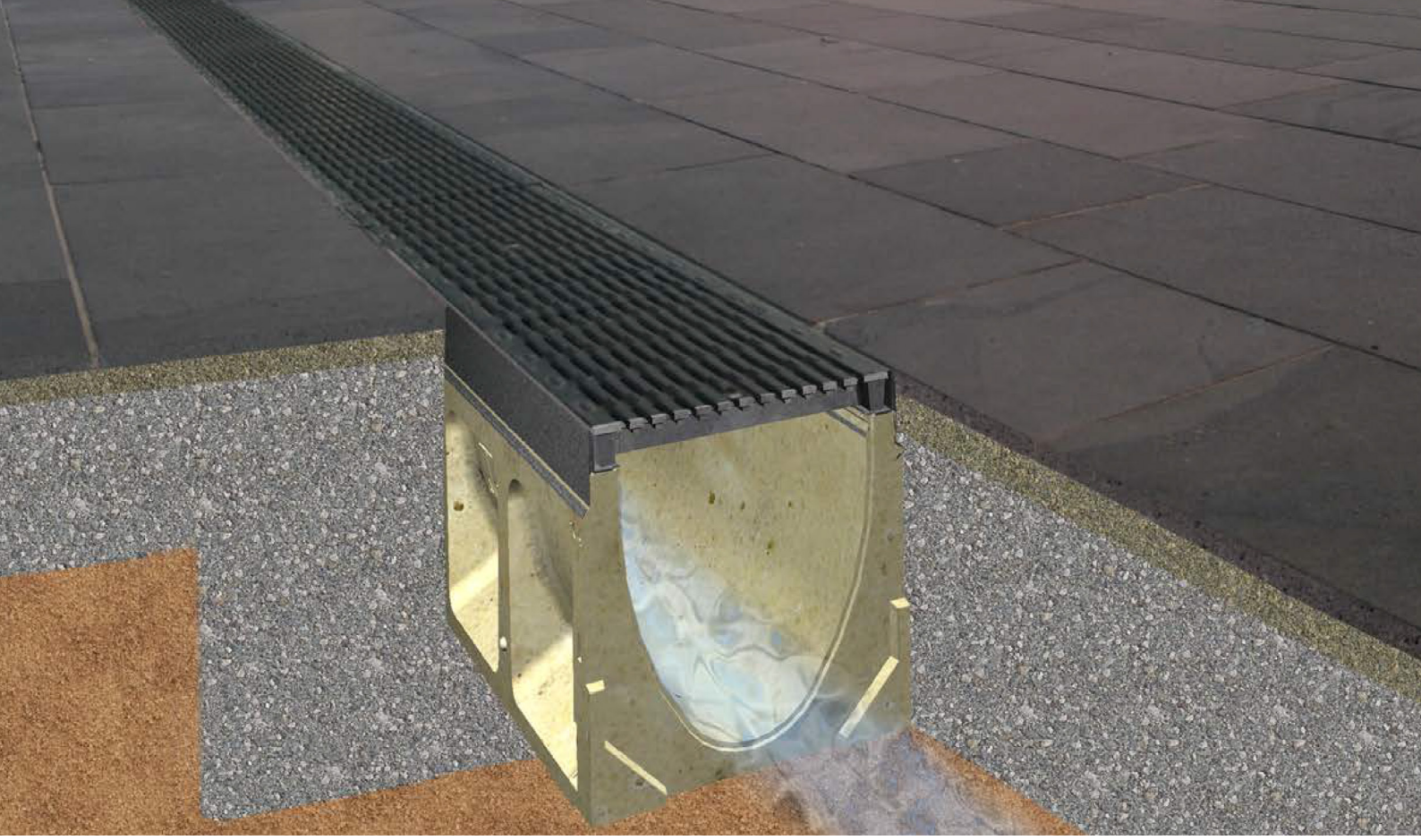
Poor pavement designs can be hazardous and ugly.

Can a surface be flat and still offer effective drainage?

It certainly can, and at the same time, it also brings countless advantages to its users and to those responsible for its maintenance.

Constructing a flat surface with effective drainage can only be achieved when designers make proper pavement design a core focus from the very earliest stage. Overlooking or diminishing this objective results in puddles, runaway shopping trolleys, slip hazards and damage to pavements.

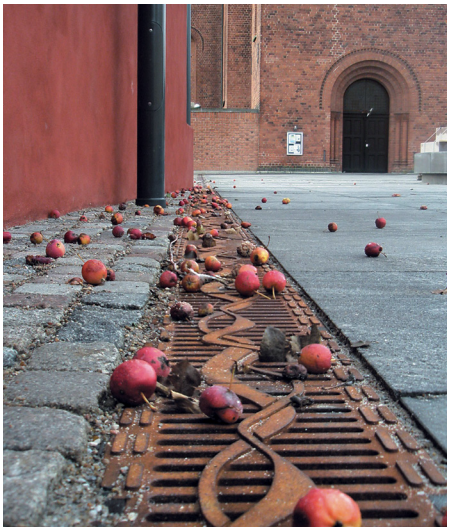
“The pavement itself must be considered a part of the drain,” says John Sordo, Manager – Marketing & Product Management at ACO. “To do this, you can have a pavement that is shaped like a traditional mattress, with lots of subtle undulations, or you can have a flat surface with gentle gradients. The latter is much safer and more convenient for users.”



"Designers, particularly landscape architects and civil engineers, generally want flat and level pavements. These pavements also deteriorate much more slowly and they allow the area to be used for a variety of purposes such as outdoor dining, walking, cycling and other activities."

There are various options for surface water management. These include the use of spoon drains, point drains and linear drains. At the concept stage, the designer must make a clear distinction of which option to use as each option will influence the final pavement design.

The key features and risks of each are outlined overleaf.



Grated trench drains

A trench drain is a continuous line of surface drainage that removes liquid from impermeable and semi-permeable surfaces.

Modular precast trench drains

Modular factory produced trench drains offer consistent quality and can be created with advanced shape profiles with a built-in slope, providing additional benefits and cost savings.

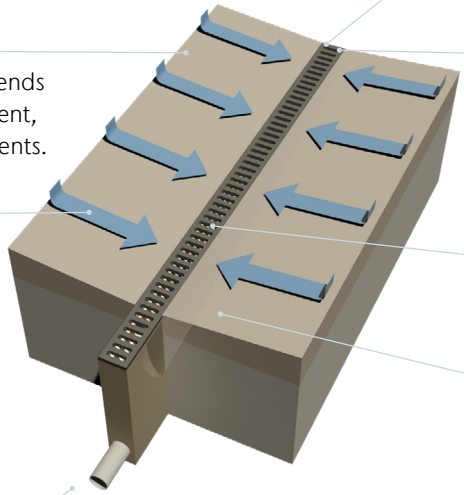
Safety
Superior liquid capture minimises hazards to pedestrians and vehicles, reducing the risk of litigation.

Pavement longevity
Reduced standing water extends the service life of the pavement, especially in harsh environments.

Grading
One-way slopes are simple, easy and quick to construct.

Maintenance
Trench drains enable easy access for maintenance and the increased flow velocity reduces the amount of sediment build-up and maintenance time.

Pipe cost savings
Minimal underground pipework is required with reduced excavation and site costs.



Initial costs
The product cost may seem high, but is offset by lower pipework and installation costs.

Narrow grates
Narrow grates are significantly cheaper, particularly in high load class applications.

Hydraulics
Narrow systems with built-in slopes create increased velocity, resulting in drainage efficiency and lower material costs.

Improved aesthetics
Grate used as a border or feature in the pavement.

Pedestrian safe
Level pavements.

Environment and health
Standing water attracts insects and bacteria. Suitable drainage enables the collection of rainwater for reuse and the collection of liquids for treatment.

Cast-in-situ trench drains

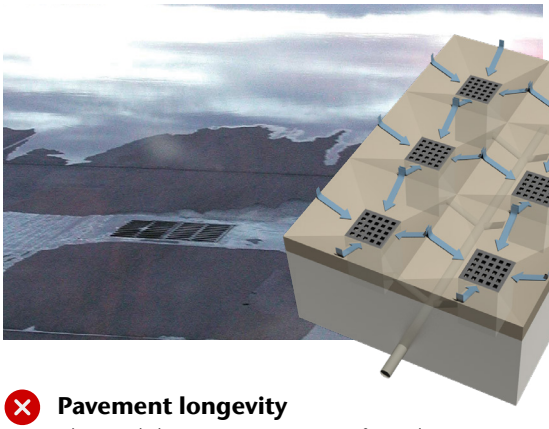
A cast-in-situ drain is created on-site during a concrete pour. It has some similarities with modular trench drains except for the following disadvantages:

- **Deterioration** of concrete surfaces especially in harsh environments, which results in lower performing hydraulics and difficult to clean surfaces.
- **Wider grates** are more expensive, particularly in high load class applications.
- **Site work** involving excavation and the construction of formwork with a slope of “V” profile can be costly. Tees and corners are difficult and time consuming to create.
- **Quality** can be inconsistent and vary greatly depending upon the contractor. It is difficult to achieve a level frame with adequate concrete support for the grate.

Alternative to grated trench drains

Point drainage

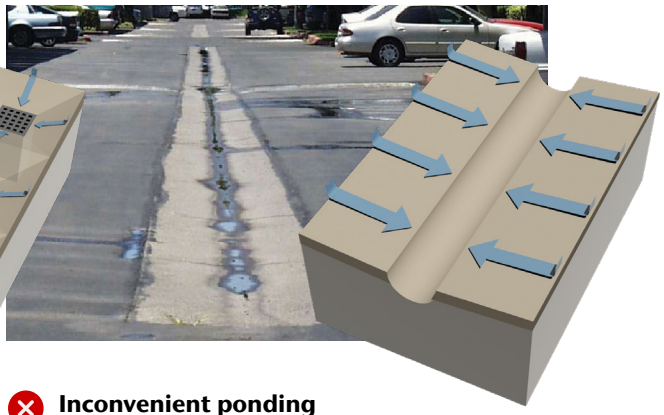
Point drainage consists of a series of grated pits located at strategic places in the pavement. Precise grading is needed for efficient drainage.



- **Pavement longevity**
  The undulating pavement surface deteriorates prematurely, especially in harsh environments, reducing the service life of the drain.
- **Frequent maintenance**
  Pipes are easily blocked by the build-up of debris requiring frequent maintenance.
- **Poor quality**
  Inconsistent pavement finish results in settlement, which leads to ponding.
- **Undulating pavement**
  Complex four-way slopes are difficult and time consuming to design and construct.
- **Costly pipework**
  Extensive underground pipework, excavation and site work required.
- **Product costs**
  Initial costs appear to be low, but is offset by higher pipework and installation costs.

Spoon drain

A spoon drain is a formed swale in the pavement, often leading to a grated pit.



- **Inconvenient ponding**
  Cannot be walked on, even with a small amount of liquid. Potential trip hazard.
- **Inefficient drainage**
  Shallow, inconsistent and irregular surface areas result in reduced hydraulic performance.
- **Maintenance**
  Requires frequent cleaning as the spoon drain easily accumulates debris.
- **Low cost**
  Quick to create with no product costs.

Do nothing

- **Property damage**
  Increased risk of property damage due to flooding and water ingress.
- **Legal ramifications**
  Risk of litigation from damage to property and/or injury to persons.
- **Environmental damage**
  Risk of environmental issues and costly clean-up and remediation expenses.
- **Reduced life of pavement**
- **No money spent**

The final choice of pavement and drainage design can demonstrate a wide difference in costs for the asset owner. According to a *case study* by global construction and property consultancy Rider Levett Bucknall, a pavement comprising precast trench drains is more cost-effective to construct than a pavement comprising point drains or drains that are cast-in-situ. Therefore proper planning can inevitably return short-term (construction) savings and long-term (maintenance, design life and liability) savings for the asset owner. Additionally, a level pavement surface allows for enhanced access and mobility for all users, resulting in walkable and usable areas. These are important determinants underpinning higher-land values.

A previous ACO whitepaper titled *Take the guesswork out of trench drainage selection* makes the recommendation that trench drains are specified as sloped systems for draining large flat pavements. This is to give engineers control over where they want the stormwater to discharge. To facilitate this further, the internal profile of the trench drain should be *V-shaped* to optimise its hydraulic efficiency. These are critical considerations for flat pavements.

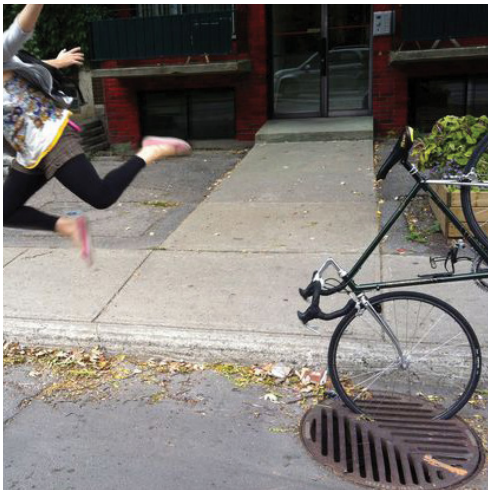
2. The trade-off between inlet size and hydraulics

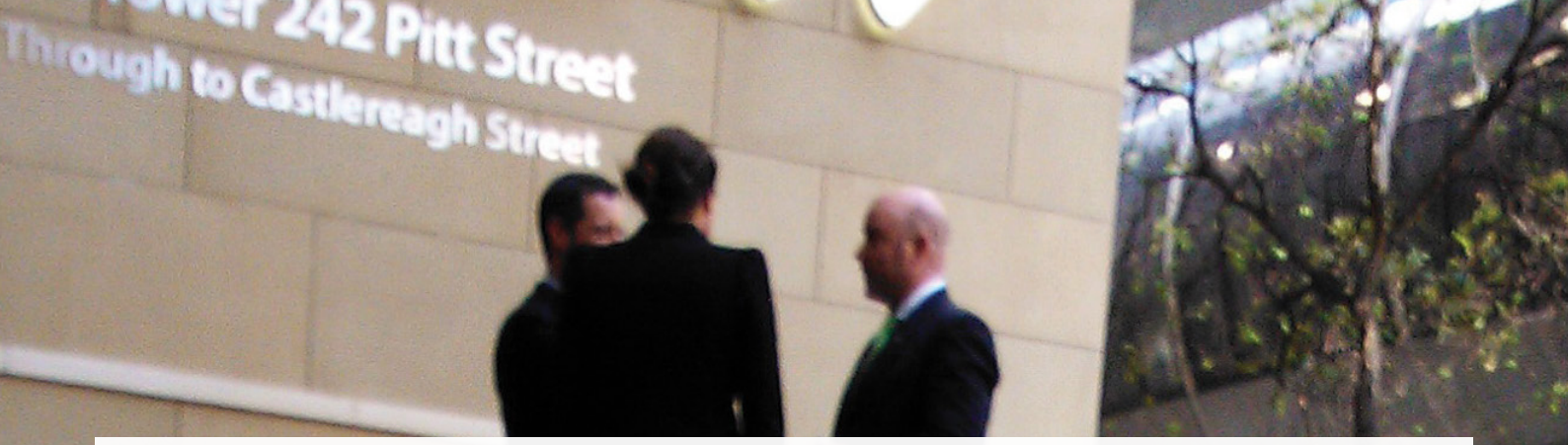
Pavements should be foot, walking cane and wheelchair friendly.

Across the industry, a slot width of 10mm is considered ideal for most applications. It offers an acceptable trade-off between foot and wheel-friendly slots and hydraulics.

A grate fails hydraulically when water can no longer enter it. Failure to deal with runoff can inconvenience pedestrians and damage buildings and their contents.

A grate's inlet (gap) size has a significant effect on its hydraulic performance and must be considered in real environments, particularly when, over time, grate inlets clog up due to silt and debris. Inlet size, however, must be kept to a minimum to stop heels, bicycles, wheelchair wheels and walking canes from getting caught.





Every project is unique. Designers must use their own judgment when deciding on the slot width required for a drainage grate. But with grates available in a variety of inlet sizes, it helps to take guidance from manufacturers and experienced designers.

The current Australian Standards – *AS 3996 Access Covers and Grates* indicates that inlets should be no more than 25mm wide. However, that recommendation doesn't take into account the various risks that exist in the modern urban environment, namely to pedestrians. There's also a serious risk to children's fingers from getting trapped and injured.

For areas where surface water volumes are low and specific protection is required for stiletto heels in dense pedestrianised spaces (e.g. outside of bars and restaurants), the *American Standard ASME A112.6.3* may be applied, restricting inlets from exceeding 8mm.

However, the ideal slot width depends on the specific features of a particular project and its context. The advantages and disadvantages of wider vs. narrower slot widths are outlined aside.

Wider slots

- Allow for better inlet hydraulics, i.e. the ability to remove water from the pavement surface
- More likely to trap heels, walking canes and other objects
- Less likely to clog up with dirt, debris, cigarette butts and leaves

Narrower slots

- Will compromise inlet hydraulics, increasing the risk of surface water to bypass and not be removed
- Less likely to trap heels, walking canes and other objects
- More likely to clog up with dirt, debris, cigarette butts and leaves

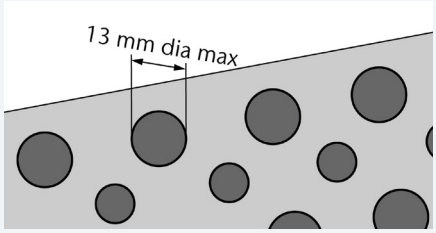
Compliance for wheelchair and walking cane safety

Depending on the inlet slot widths and slot orientation, grates can be a hazard for people who use wheelchairs and for people with ambulatory or sensory disabilities, for example, trapping wheels/canes in the grate slots.

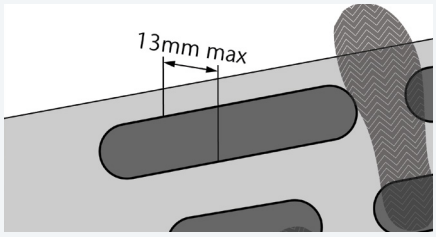
New building works must be designed to comply with the *Disability Discrimination Act (DDA)*. The DDA makes it illegal for public places to be inaccessible to people with disabilities.

AS 1428.1:2021 includes *Section 4: Floor or ground surfaces on continuous accessible paths of travel and circulation spaces*, with Clause 4.4 *Grates* stating the following: "Grates in paths of travel shall be in accordance with the following:

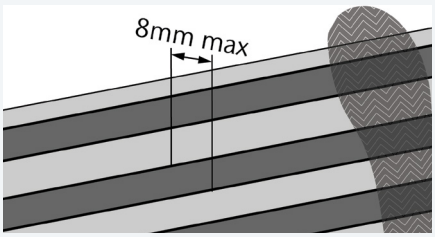
a. Circular openings shall be not greater than 13mm in diameter.



b. Slotted openings shall be not greater than 13mm wide and not greater than 150mm long and be oriented so that the long dimension is transverse to the dominant direction of travel.



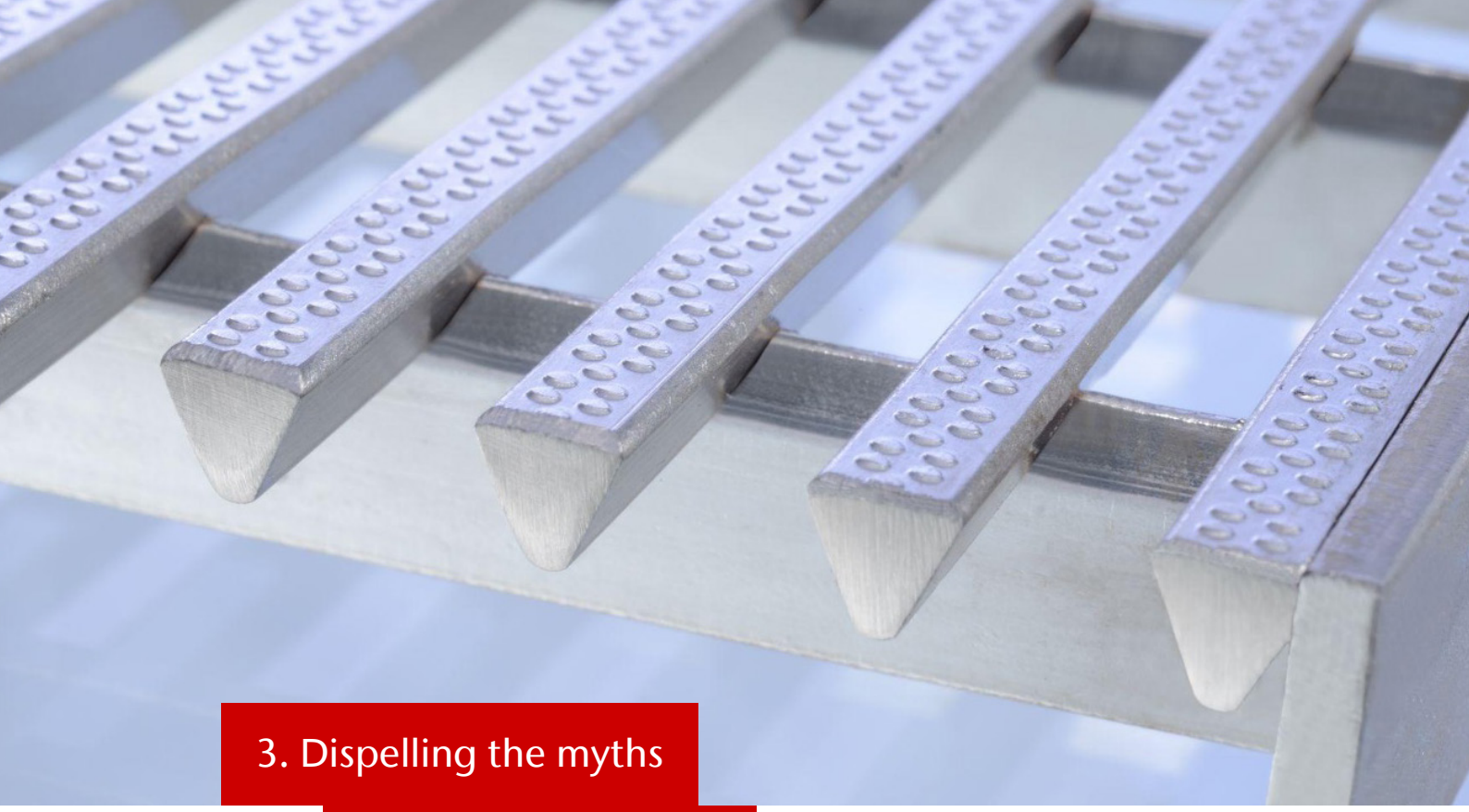
c. Linear openings shall be oriented so that the longer dimension is transverse to the dominant direction of travel, except where linear openings are less than 8mm wide. Where linear openings are less than 8mm wide, orientation is optional."



AS 1428.2-2009 contains *Clause 9 Ground and floor surfaces*, with sub-clause (c) *Gratings*, which states:

"If gratings are located in a walking surface, they shall have spaces not more than 13mm wide and not more than 150mm long. If gratings have elongated openings, they shall be placed so that the long dimension is transverse to the dominant direction of travel."

Note, AS 1428.1:2021 Clause 4.4 (b) is the same as AS 1428.2-2009 Clause 9 (c).



3. Dispelling the myths about slip resistance

Grates must be slipped rated to AS 4586.

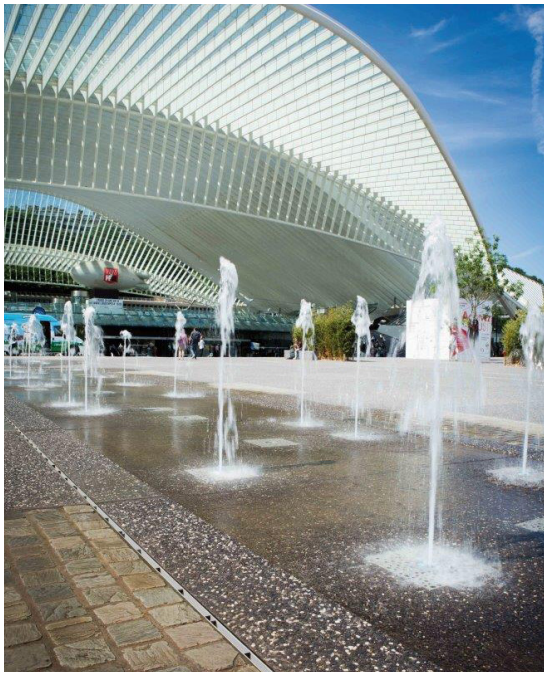
A higher slip resistance rating does not necessarily provide a better solution.

A considerable amount of research has gone into assessing the necessary slip resistance levels required for pavement and floor elements - tiles, pavers, covers and grates. It's also an area that is highly regulated.

"There is a widely-held belief that the more slip resistant a grate is, the safer it is," Darren Chan says, ACO's Brand Manager - Civil Construction Products. "But that's really not the case."

"If you have a grate that is more slip resistant than the rest of the pavement, it creates a trip hazard. So we recommend as a default, and in the absence of any other available information, that the grate be designed to have the same level of slip resistance as the pavement. That's the safest solution."

A trip hazard may occur when a grate has a higher slip resistance than the surrounding floor surface. A slip



hazard may occur when a grate has a lower slip resistance than the surrounding floor surface.

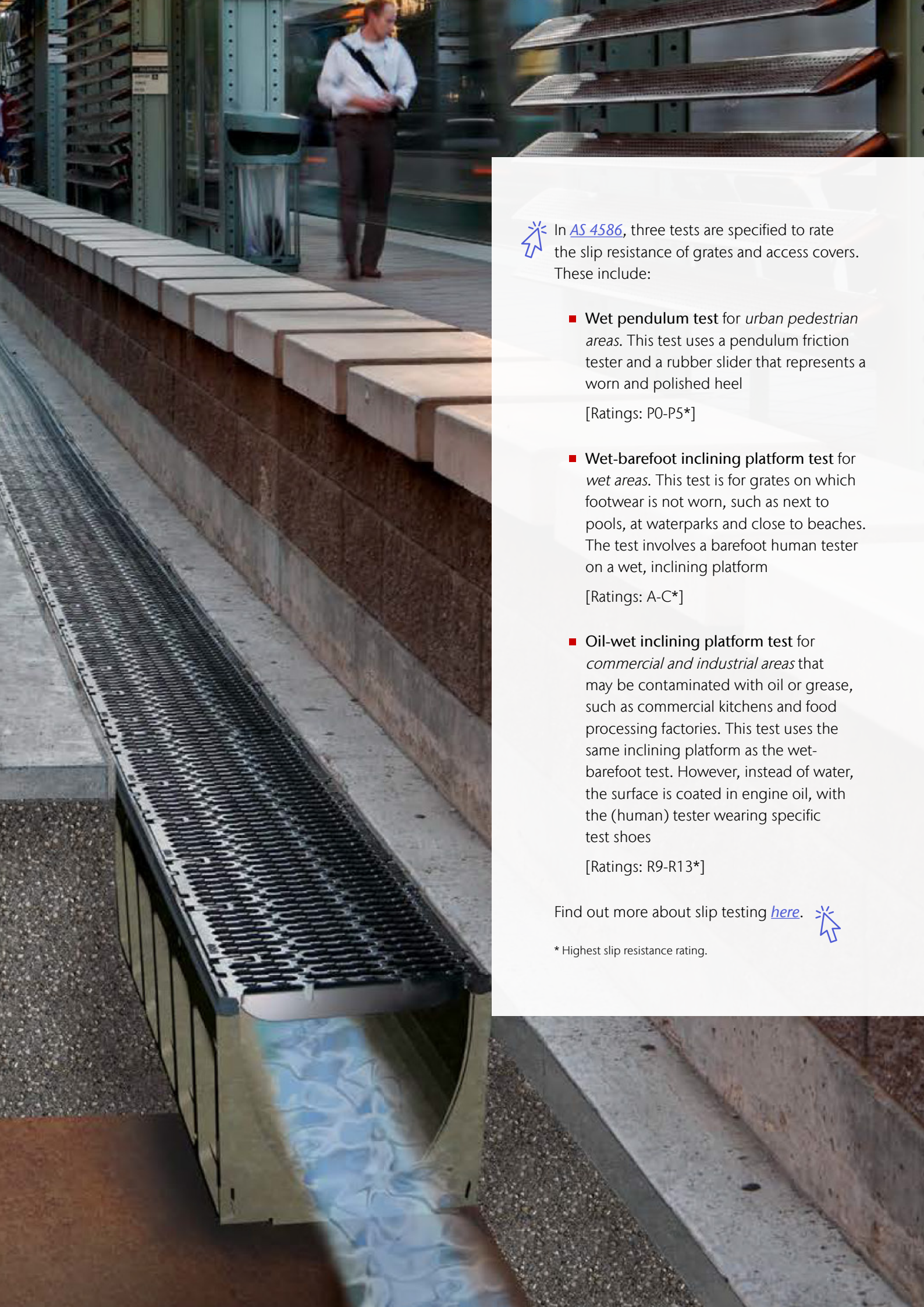
"Some designers opt for slotted tops as a discreet choice. This ensures a consistency of slip resistance over the drain." Chan adds.

Table 4 – Minimum classifications recommended in SA HB 198:2014 for particular applications

Location	Wet pendulum test*	Inclining platform test*
External Pavements and Ramps		
External ramps including sloping driveways, footpaths etc. steeper than 1 in 14	**P5**	**R12**
External ramps including sloping driveways, footpaths etc., under 1:14, external sales areas (e.g. markets), external carpark areas, external colonnades, walkways, pedestrian crossings, balconies, verandas, carports, driveways, courtyards and roof decks	**P4**	**R11**
Undercover car parks	**P3**	**R10**
Hotels, Offices, Public Buildings, Schools and Kindergartens		
Entries and access areas including hotels, offices, public buildings, schools, kindergartens, common areas of public buildings, internal lift lobbies		
Wet areas	**P3**	**R10**
Transitional area	**P2**	**R9**
Dry area	**P1**	**R9**
Toilet facilities in offices, hotels and shopping centres	**P3**	**R10**
Hotel apartment bathrooms, en suites and toilets	**P2**	**A**
Hotel apartment kitchens and laundries	**P2**	**R9**
Supermarkets and Shopping Centres		
Fast food outlets, buffet food servery areas, food courts and fast food dining areas in shopping centres	**P3**	**R10**
Shops and supermarket fresh fruit and vegetable areas	**P3**	**R10**
Shop entry areas with external entrances	**P3**	**R10**
Supermarket aisles (except fresh food areas)	**P1**	**R9**
Other separate shops inside shopping centres – wet	**P3**	**R10**
Other separate shops inside shopping centres – dry	**P1**	**R9**
Loading Docks, Commercial Kitchens, Cold Stores, Serving Areas		
Loading docks under cover and commercial kitchens	**P5**	**R12**
Serving areas behind bars in public hotels and clubs, cold stores and freezers	**P4**	**R11**
Swimming Pools and Sporting Facilities		
Swimming pool ramps and stairs leading to water	**P5**	**C**
Swimming pool surrounds and communal shower rooms	**P4**	**B**
Communal changing rooms	**P3**	**A**
Undercover concourse areas of sports stadiums	**P3**	**R10**
Hospital and Aged Care Facilities		
Bathrooms and en suites in hospitals and aged care facilities	**P3**	**B**
Wards and corridors in hospital and aged care facilities	**P2**	**R9**

*See overleaf for explanation of ratings

For more details refer to Section 5 and Table 3B, SA HB 198:2014



In *AS 4586*, three tests are specified to rate the slip resistance of grates and access covers. These include:

- **Wet pendulum test** for *urban pedestrian areas*. This test uses a pendulum friction tester and a rubber slider that represents a worn and polished heel

  [Ratings: P0-P5*]

- **Wet-barefoot inclining platform test** for *wet areas*. This test is for grates on which footwear is not worn, such as next to pools, at waterparks and close to beaches. The test involves a barefoot human tester on a wet, inclining platform

  [Ratings: A-C*]

- **Oil-wet inclining platform test** for *commercial and industrial areas* that may be contaminated with oil or grease, such as commercial kitchens and food processing factories. This test uses the same inclining platform as the wet-barefoot test. However, instead of water, the surface is coated in engine oil, with the (human) tester wearing specific test shoes

  [Ratings: R9-R13*]

Find out more about slip testing *here*.

* Highest slip resistance rating.

4. Correct Material selection delivers durability and strength benefits

Material selection can impact design life.

Strength and durability are both vital considerations when it comes to maximising the full design life of pavement elements.

Products that do not match the service life of the project could undermine the walkability of the pavement.

Early in the design process, there are numerous project specific questions to ask that can influence the correct choice of material.

These include:

- What is the current and intended future use of the pavement?
- Will the pavement be pedestrian only and, if so, is it likely that it will need to handle heavy trolleys?
- Will the pavement need to accommodate traffic from cars and trucks, and could they be braking or turning on the grate?
- What are the weights and types of wheels that the pavement will need to withstand?
- Will the grate be installed near the coast or a swimming pool?
- Will chemicals be used for cleaning the pavement?

“If a drain fails because something too heavy has gone over it, it immediately becomes unsafe, because components are no longer tied down,” Chan says.

“It is a hazard under wheel traffic, but it also becomes dangerous in shared zones and pedestrian-only areas.”

The Standard AS 3996 *Access Covers and Grates* specifies the requirements for grates used in all types of areas, from pedestrian to heavy duty traffic, footpaths to major roads, and freeway shoulders to loading docks.

The trench drain system is an 'integral part' of the pavement. Therefore:

- Specifying drains for strength is important. There is no current Australian Standard that specifically deals with trench drains. AS 3996 specifies the requirements for grates for use in pedestrian and vehicular areas. The only standard written specifically for grated trench drains that is internationally recognised is EN 1433. This standard includes different grate widths and channel sizes.
- Specifying drains for durability is important:
  - Channel bodies need to be of a strong and rigid design
  - Iron grates are very robust
  - Stainless steel and plastic grates offer high resistance to corrosion
- Specifying the correct installation detail is important. This requires knowledge of the structural pavement and how and what loads are trafficking the pavement, both in the short and long term.

Getting the above three factors correct will ensure the design life of the trench drain will match that of the pavement.

"The method by which the *grates are locked down* can also affect the durability," Chan says. "Options include boltless locking, bolt locking and security bolts for use in sensitive areas, such as in a military application."

AS 3996: 2019 - Table of load classifications

						
10kN *Extra light duty*	80kN *Light duty*	150kN *Medium duty*	240kN *Heavy duty*	400kN *Extra heavy duty*	600kN *Extra heavy duty*	900kN *Extra heavy duty*
Typical Uses						
Footpaths and areas accessible to pedestrians and cyclists	Residential properties and footpaths suitable for light vehicles	Malls and pedestrian areas open to slow moving commerical vehicles	Major roads, freeway shoulders and loading decks	Carriageways of freeways and heavy industrial areas	Docks and aircraft pavements subjected to high wheel loads	Docks & aircraft pavements subjected to very high wheel loads
Aproximate Nominal Wheel Load						
330 kg	2,670 kg	5,000 kg	8,000 kg	13,700 kg	20,000 kg	30,000 kg

5. Believe it or not, grates and drains can tell a story

Like pavements, grates visually interact with the environment.

Public art is playing an increasingly important role in connecting the people of a city with its past. Some designers are leading the way by, quite literally, putting that art at the feet of the people.

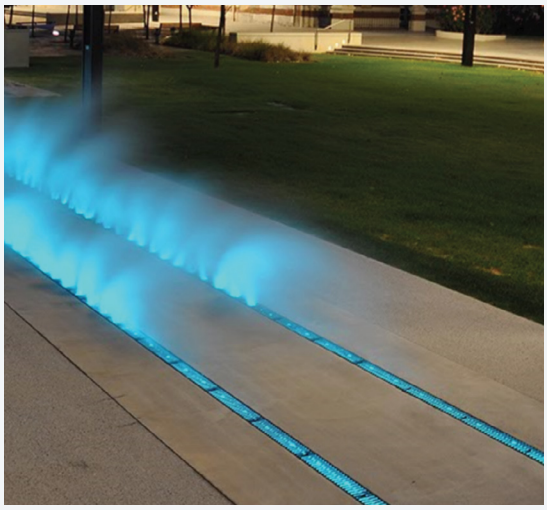
The *Market to Riverbank Link* in Adelaide is a vibrant and visually engaging thoroughfare intended to captivate locals and visitors alike with its street art, creative lighting and canopies of tree branches. Even the drains tell a story.

The grates that run the length of the paved footpath were designed to reflect the natural shapes of geode mineral deposits. They were designed by an Adelaide-born artist and inspired by the geology of the local area. (See image bottom right).

Similarly, in a *public space at the University of Sydney*, outside the Faculty of Arts and Social Sciences building, Indigenous culture meets urban design with a grate that creates an aesthetically-pleasing flowing-water pattern.

At *Sydney's Pitt Street Mall* a centrally positioned trench drain boasts a grate with an underlying lighting system. The artwork has been designed to connect people with the Tank Stream, Sydney's original source of fresh water.

At *Angel Place, Sydney*, the trench drain was made to harmonise with the historical iron, steel and granite elements in the laneway.



At *Midland Railway Square, Perth*, the grates are incorporated to provide a linear misting and lighting feature to pay homage to the steam engines of the past.

Aligning interests for the same outcome

Desired aesthetics inevitably affect material choice. While some designers appreciate the fact that iron can discolour, others opt for a mix of alternative materials to achieve their unique look and style.

"The designer needs to look at performance-related factors. The landscape architect looks to the majority of the stakeholders – including the client, environmental groups and Indigenous groups – to tell a story that could be reflected in the design of the grate and elsewhere." Sordo says.

"The client has to live with the result," Sordo says. "And so everybody in the design process has a very important role to play."

Each stakeholder has a specific interest and outcome they're aiming to achieve in the project.

"Drainage is a topic that vibrates in a different way, depending on the stakeholder. But in the end, everyone wants a cost-effective, durable, attractive and safe solution. With surface water drainage, that is absolutely possible if the right people are brought into the design process early enough."


ESKAU

ACO can provide a number of free services to help asset owners and designers achieve drainable, level pavements for improved walkability:

- A *comprehensive evaluation* to assist designers at the preliminary and detailed design stages of the project with an emphasis on:
  - Minimising earthworks and pipework
  - Using existing pavement levels and drainage infrastructure
  - Integrating other water management requirements, for example *OSD*, *rainwater harvesting* and other WSUD initiatives
- *Assign services and online tools* relating to hydraulics, schematic layouts and *customisation*
- *Installation* drawings and advice
- *ACO's Heelsafe® Anti-Slip grates* provide an ideal solution for surface water collection, level walking surfaces, slip resistance, durability and heel safety. The range comprises grates with inlets not exceeding 10mm wide slots, enabling designers with the right balance between pedestrian safety and surface water collection. The grates:
  - Are load tested and NATA endorsed to AS 3996
  - Comply with bicycle tyre resistance criteria of AS 3996
  - Comply with wheelchair and walking cane safety requirements of AS 1428
  - Are slip tested and rated to AS 4586

These services are offered free and without obligation.

About ACO

ACO Australia has over 25 years of local experience in supplying project specific solutions with Australian Made trench drainage systems.

This is backed by the company's strong in-house design resources and technical team of engineers and specialist sales professionals. ACO's partnerships with universities in Australia and overseas mean that its trench drainage solutions are supported by rigorous empirical testing.

askACO

askACO is a corporate initiative designed around advice and industry education. Services are offered free of charge without obligation and are designed to complement (not substitute) professional engineering advice. For more information, or to use our free design service to meet your individual project requirements, contact ACO today or visit www.askACO.com.au

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