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Summary Bulletin

Ramps

PEER REVIEWED

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Executive Summary

Accessibility problems have a serious impact on the quality of life of people with reduced mobility or those dependent on mobility aids. One of the most crucial problems is the difficulty to make even small vertical level changes, such as traveling up and down stairs in their home. Ramps are the most common solution for joining different levels and their characteristics for safe use are described in the National Construction Code (NCC) and in the Australian Standards. The requirements described in NCC and the Australian Standards though (mainly AS 1428.1 2009), are not mandatory for all types of residential environments, where more choices are available and the ramp design is more flexible.

This publication, uses information from the NCC, a number of Australian Standards, handbooks, guidelines and other valid scientific and technical sources to provide a summary of the facts and issues related to the main design and construction parameters of ramps. It also attempts to identify the major hazards that this intervention type presents to the users, by focusing on the following aspects:

- Gradient and Length;
- Width;
- Ramp Geometry;
- Materials;
- Ramp Surface
    a. Slip resistance;
    b. Tipping and tripping;
- Turns/switchbacks;
- Landings;
- Handrails;
- Camber/Crossfall;
- Maintenance;
- Environmental, aesthetic and/or social parameters.

The aim of the document is to provide information to the end users and the industry about the result of their choices for each of the main ramp aspects on the safety and general acceptance of the ramp.

Keywords

Ramps; accessibility; design parameters; gradient; home modification; disability

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Contribution of Authors

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Catherine Bridge also developed part of the content and provided guidance on the information included in this document. She also reviewed the Summary Bulletin.

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General design requirements for accessibility ramps

Ramps are usually used to join small changes in height, such as the height between the street level and a building entrance, or when the installation of a lift for connecting floors is difficult or undesirable. In home modifications, ramps are most commonly installed to provide access from the road, front yard or garage to the house interior, to join small changes in height, such as on the door threshold and/or for connecting two interior spaces, which are on the same floor, but on different levels. Using a ramp for joining different floors would require too much space and is not common in residential buildings.

It is important to choose the ramp characteristics and elements that suit the main ramp user and/or their carers' needs and abilities. This requires close collaboration between the ramp owner and the builder. However, the characteristics of the environment where the ramp will be installed are also important and determine the performance and appearance of the ramp by the end of its useful life. The main parameters defining the quality and ease-of-use of a ramp, are analysed in the following paragraphs.

Gradient and Length

The gradient (inclination) of a ramp is one of the most important parameters of its design and is related to its length. The choice of a ramp gradient for a specific home modification application depends on the height difference between the two levels that need to be joined, the preference and/or ability of the users (force/effort that someone must put to traverse the ramp), the available space, as well as environmental, aesthetic and/or social parameters.

The minimum gradient for a walkway to be considered a ramp, according to AS 1428.1-2009, is 1:20. The Australian standards require the maximum gradient of a ramp, intended to be used by wheelchair users, with a length greater than 1900mm, to be no greater than 1:14.

It is advised that ramps in home modification projects should not exceed the recommended gradient range (1:20 to 1:14), unless the main user uses a mobility scooter or powered wheelchair, allowing them to safely traverse a steeper ramp. However, users of powered wheelchairs and scooters should get information about the maximum gradient that their mobility aid can traverse from the aid manufacturer. Generally, ramps steeper than 1:6 should not be constructed, as the average user will not be able to negotiate them. Also, there is a risk that some wheelchairs might tip due to shifting of the centre of gravity in relation to the wheels and of the weight of the mechanisms/batteries that are usually placed on the rear of the chair (Access North & Metropolitan Centre for Independent Living) and/or they might fail to limit their speed, due to the powered wheelchair capabilities (EBEP, 2017).

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Some walking or manual wheelchair ramp users would be willing to traverse a ramp steeper than the recommended (for example, 1:10 or 1:8) if the length was shorter, as great distances tend to increase the fatigue effect (Graves Wolfmbarger, K. and Shehab, R., 2008). Fine tuning of the ramp design (gradient-length) is an efficient technique for temporary applications, where the strength of the main user is not likely to change significantly during the useful life of the ramp. However, a permanent ramp should always be designed to accommodate not only the current, but also the future, anticipated needs and abilities of the users. If the gradient of the ramp, that can practically be constructed in a specific project is greater than 1:6 or greater than what the user can traverse, the solution of a vertical lift or a stairlift should be considered.

Researchers have provided data that some people with ambulant disabilities (like people with hemiplegia or lower extremity amputation) may actually prefer steps to ramps, especially for descending (Rockwell Collins Retiree Volunteers and Wheelchair Ramp Assistance Program, 2015, Barnes, 1991). This implies that if more than one user of the property have ambulant disabilities the stairs should probably be kept, and the ramp design should address everyone's needs.

Width

The minimum width of a public ramp, or any other continuous accessible path of travel, as recommended in AS 1428.1-2009, should be at least 1000 mm, unless the ramp or pathway is curved, in which case the minimum width should not be less than 1500mm (see Ramp Geometry section). When a ramp is designed to allow two wheelchairs to pass, the minimum width should be at least 1800 mm, for a minimum length of 2000mm.These apply to net width, which should not be obstructed by fixtures, fittings, opening doors and windows, fire hose reels, fire extinguishers, door handles (less than 900 mm above the finished floor level), handrails, etc.

However, the width of a home ramp depends on its potential use and probably does not need to accommodate two users, unless the person with the disability needs to be supported by a carer or accompanied by a guide dog. The widths of mobility scooters can vary substantially, from 460 mm to 780 mm, while wheelchairs can have a total width of 580 to 850 mm. So, a ramp accommodating a scooter or wheelchair user should have a width appropriate for the equipment used or any future anticipated upgrade. The measurement of the width of the mobility aid while in use would be the best reference for selecting the final ramp width.

Ramp Geometry

Ramps should provide the most direct access to an interior. However, depending on the application and the environment, different layouts of ramps can be constructed. The four main types of ramps, are:

- Straight ramps: Those are ramps with or without landings depending on their length, that have no turns. They could be placed so that the direction of

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movement is at an angle to the opening/door, or they could be attached to the wall which includes the opening;

- Ramps with switchbacks: These ramps have two runs linked by a landing, where the users can change their direction of movement by 180^{o};
- Ramps with turns: These ramps have two runs linked by a landing, where the users can change their direction of movement by a degree smaller than 180^{o};
- Curved ramps: Ramps with run following a curved line.

The choice of ramp layout depends on the available space and the height that needs to be reached. Straight ramps are most commonly used when they can be attached to an interior or exterior wall or when a large exterior space can be used to install a ramp that leads directly to the building entrance or a porch.

Ramps with turns and switchbacks are usually constructed when the height to be covered is relatively high but the available space (length) is limited. However, tight turns or switchbacks should be avoided where possible, as users of non-standard wheelchairs might not be able to traverse them. Additionally, turns could prevent ambulance trolleys access, leading to unnecessary deaths (Bridge and Carnemolla, 2014).

Most curved ramps have compound slopes. That means that the cross section of the ramp is usually not horizontal as it leans towards the centre of the circle. The curvature and slope make traversing the ramp difficult and potentially dangerous, as not all wheels rest evenly on the surface (U.S. Access Board, Guide to ADA Standards, 2010. Chapter 4, Accessible Routes. Ramps and Curve Ramps). In order to design and construct a curved ramp that will be safe for wheelchair users, the width has to be much greater than that of straight ramps.

The advantages and disadvantages of the four main ramp geometries are summarized in Table 4.

Materials

The National Construction Code has specific requirements about the materials of ramps for buildings with more than 2 storeys, to avoid the hazard of ramp failure in case of fire (non-combustible materials or materials with high resistance to fire are required) (D2.2, NCC 2016).

A wider variety of materials can be considered for domestic ramps. The most commonly used materials for ramps are wood or composite timber, aluminium and concrete. The material on the surface of the ramp could be different than the rest of the structure, or a treatment could be added to make the surface more slip resistant, more durable and/or resilient.

The environment where the ramp is constructed/installed and whether it is going to be exposed to exterior conditions or not are very important factors for the selection of the ramp material. For example, rain water and fallen leaves can make the surface of

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almost all types of ramps slippery and they might even cause rotting of wood ramps. Also, UV radiation might cause degradation of a surface treatment or coating. Generally, ramps made of wood or metal that are exposed to exterior conditions require frequent maintenance and cleaning. Although concrete ramps are more durable and not easily affected by weather, they are usually more expensive to install than other options.

The cost of the ramp material during its entire life cycle should be considered. That means that not only the construction/installation cost should be taken into account, but also the cost for the maintenance and cleaning of the ramp, in relation to the expected life (for how long is the ramp expected to be used). For example, if the ramp is installed for someone using a wheelchair because of a broken leg, it shouldn't be constructed by a very expensive material, as it will soon be removed. Metal and wooden ramps are good solutions for short/medium-length use. On the contrary, if a ramp is to be used for many years, a permanent and durable solution is advised.

Durability should also be considered when designing and constructing a ramp. Different ramps can bear different loads, however, all types of ramps will be able to support almost any weight if they are appropriately designed. For that reason, users of wheelchairs and scooters should know the combined weight of their mobility aid and of their own body before asking for quotations for home ramps or assigning the construction of a home ramp to a builder.

The appearance and comfort during use are important parameters for wheelchair users and for people walking barefoot. The use of carpet for the ramp floor impacts on many mobility functions, like shuffle walking/ walking frame use and the rolling resistance of wheelchairs. Even though there are no pile height requirements for the carpets used in private houses, the requirements of the National Construction Code for carpets used in accessible public spaces could be used as guidance when purchasing carpet for a home ramp. NCC requires that the pile height or pile thickness of the carpet shall not exceed 11 mm and the carpet backing thickness shall not exceed 4 mm. Designers and/or consumers should request a test certificate with reference to the conditions of the testing when choosing carpet for interior ramps.

Metal exterior ramps should be avoided when they are going to be used by people walking barefoot, as they could get hot when exposed to solar radiation. Choosing a material for an exterior ramp that blends well with the rest of the building fabric (materials of the house) or garden offers better aesthetic results and reduces the institutional appearance of the property.

Property owners and contractors should bear in mind that the design and construction of an exterior ramp might require a building permit, depending on the local regulations. The material of the ramp might need to be approved as well. Also, when the private dwelling for which the ramp is designed and constructed is an exempt or complying development under the State Environmental Planning Policy (Exempt and Complying Development Codes) 2008, exterior access ramps should comply with specific

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standards. For more information on the standards for the access ramps of complying developments, you can visit the NSW legislation website here.

The advantages and disadvantages of the main ramp materials are summarized in Table 5.

Ramp Surface

The term ramp surface refers to the run of the ramp, or the part of the ramp people traverse. The ramp surface could be from the same material as the rest of the ramp structure or could comprise a top layer, for example tiles on a concrete structure or wood on a metal structure.

The main characteristics that should underpin the decision for the ramp surface material and design/construction are the slip resistance and rolling resistance, as well as the hazard of tipping and tripping, as ramps are included in the environmental parameters that might cause slips, falls and trips. Slipping on ramps is one of the most common issues, which can be attributed to a steep gradient, a slippery or improperly maintained surface or/and improper shoe soles. Tripping is usually caused by bad design or construction of the ramp surface.

Slip resistance

Slipping while walking or traversing a pathway on a wheelchair, depends on a number of parameters, which should all be taken into account when choosing a material for the ramp surface:

- The slip-resistance of the material, affected by the material nature, maintenance, wear characteristics, etc;
- The gradient of the surface;
- The type of the users (gait, age, etc);
- The footwear;
- Other environmental factors, like absence of handrails, lighting, etc (SA HB 198:2014).

Ramps, like all continuous accessible paths of travel and circulation spaces should have a slip-resistant surface, to avoid shoe heels, wheels and walking aid tips from slipping.

The National Construction Code gives the slip resistance requirements for the elements associated with ramps (landing surface, nosing or landing edge strip) and for the various ramp gradients in public accessible spaces, when the new floor surface is tested according to AS 4586 (Table 1). These requirements are advisory and can be used as guidance for private dwellings.

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Table 1. Slip Resistance Requirements for ramps

Application	Surface Conditions	
	Dry	Wet
Ramp steeper than 1:14	P4 or R11	P5 or R12
Ramp steeper than 1:20 but not steeper than 1:14	P3 or R10	P4 or R11
Tread or landing surface	P3 or R10	P4 or R11
Nosing or landing edge strip	P3	P4

Source: D2.14, National Construction Code 2016 © 2016 Commonwealth of Australia and States and Territories of Australia

Notes: The higher the number of the classification of the material, the more slip resistant it is. For example, a material with a slip resistance classification P4 is more resistant than a material with slip resistance classification P3. A surface is considered dry if it does not get wet under normal conditions or it could get wet by an accidental spill. A wet surface is always or usually wet, including surfaces exposed to weather (NCC 2016, Volume 2, pg 361).

The suitability of a material for a home ramp, depending on its gradient and surface conditions, can be checked by obtaining its slip resistance classification (according to Table 1), by its manufacturer or supplier. It should be stressed, however, that this classification applies to new materials. After extended use of the ramp or exposure to weather conditions that affect the surface, the material slip resistance classification is invalid and maintenance should occur. Also, the tests that lead to these classifications are not appropriate for highly-profiled materials, to which other tests apply.

The slip resistance classification of some materials cannot be determined before the ramp construction. For example, ramps made from concrete poured on-site must be tested after the construction of the final layer of the ramp floor. However, there are certain additives and surface treatments, like wood-floated, broom finished or exposed aggregate surfaces that ensure a good slip resistance for any user.

The slip-resistance of timber, concrete, stone and porcelain can be increased with the use of special coatings. The manufacturers of these coatings provide a slip resistance classification which is valid when the products are applied to specific floor materials.

For examples of floor materials with a slip-resistance classification greater than P3 or R11, please refer to the HMinfo Industry Factsheet: Slip Resistance of Ramps and its appendix. Also, Appendix 1 of the current publication includes recommendations for the appropriateness of various floor materials for inclined surfaces, based on the Compliance Document for New Zealand Building Code, Clause D1: Access Routes – 2nd Edition.

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When a ramp surface is wet, it is more slippery than when it is dry. When a slip resistant material is combined with a canopy covering the ramp that is exposed to weather, its use becomes much safer. Apart from the actual slip-resistance of a ramp material, its appearance should also be considered. Surfaces that appear to be shiny and slippery, even if they are not, may cause anxiety to older people and people with mobility aids, which could actually lead to increased risk of slipping (Commonwealth Experimental Building Station (Australia) - Department of Housing and Construction, 1981).

On the other hand, rolling resistance can slow down the users traversing the ramp or increase the risk of tipping, due to high friction at the contact interface. Therefore, very rough materials should be avoided.

Tipping and tripping

Another hazard presented to older people and people using mobility aids while traversing ramps is tripping and tipping. Tipping can occur when there is a change in level from the main ramp surface, when there is a sudden change in the ramp gradient (transition), when the ramp material is highly profiled or when gratings are used.

According to AS 1428.1, to avoid tripping and tipping, abutment of surfaces should have a smooth transition. Even though the design transition should be 0mm, the construction tolerances can be up to 5 mm, when the edges are rounded or bevelled. A construction tolerance lower than 3 mm can have a vertical edge.

Highly-profiled materials and gratings are very common materials for exterior ramps. They can present a hazard for people with walking sticks, as their ends could get stuck in the openings. Also, wheelchairs wheels could fall in the openings or gaps and excessive force might be needed to get the wheels out of these gaps. To avoid accidents, gratings should have maximum openings of 12 mm while the bars should be at least 13 mm wide. Raked joint pavers (where the mortar is not flush), or other high-profiled materials, should have a maximum width of mortar joints or holes equal to 12 mm with a 2 mm maximum depth, according to AS 1428.1. These dimensions ensure that the openings are smaller than the tip of canes or the diameter of the wheels.

Sudden changes in the gradient (transitions) or bumps on the ramp surface can cause some wheelchairs to tip. Transitions can pose issues for wheelchairs, as manual wheelchairs' caster wheels can get caught up on them, especially where a user has limited upper body strength, even with a power assist mechanism. Powered wheelchairs can also be trapped because of a bellying, grounding or sagging effect, caused when a footplate or footplate locking pin (many wheelchairs have these) catches and snags on the uneven ramp surface. Front and centre wheel drives can also be a problem. Sudden changes in ramp gradient or uneven surfaces should generally be avoided (Gibson et al, 2016).

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Turns/switchbacks

The recommended circulation spaces for wheelchairs, according to AS 1428.1, are given in the following table. These requirements are advisory for private dwellings. However, wider turning spaces could be required in specific situations, for example for people in wheelchairs who can only have their legs extended.

Table 2. Circulation space requirements for wheelchair turn

Turn	Minimum required space
30º-60º	For widths smaller than 1200 mm, a splay or apron that extends outward at least 500 mm x 500 mm should be made
60º-90º	1500 mm wide and 1500 mm long
90º-180º	2070 mm in the direction of travel and not less than 1540 mm wide

Source: Australian Standard AS1428.1. Clauses 6.5.1, 6.5.2, 6.5.3, pg. 11-13.

As it has already been mentioned, ramps with sharp curves, turns and switchbacks are not recommended for users of non-standard wheelchairs, as it is difficult for their users to make a 180º turn. Paramedics would also face difficulties taking ambulance trolleys up/down ramps with turns and without appropriate landing. Large landings are required to solve this problem. However, the space needed for such a solution is rarely available in private dwellings, thus it may be more practicable to consider other solutions, such as a lift.

Landings

The absence of a landing between a ramp and a door (usually the building entrance) is not a rare phenomenon. This omission makes opening doors difficult and dangerous to people using mobility aids or having stability issues. Landings on ramps are required to ensure the safe change of direction, access to openings and the comfort of the users. The gradient, width and spacing of the landings, depend on the ramp slope and whether the landing is used for direction change or not. The requirements for landings, according to AS 1428.1, are summarized in the following table. This information is advisory for private dwellings.

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Table 3. Requirements for ramp landings (advisory information)

	Gradient	Width	Length	Spacing
Landing with no change in direction	Not steeper than 1 in 40 or 1 in 33 where the surface is bitumen	1000 mm minimum unobstructed	1200mm minimum	Ramp gradient 1 in 14: 9m maximum Ramp gradient 1 in 20: 15m maximum Between 1 in 14 and 1 in 20: by interpolation
Landing with up to 90º change of direction		1500 mm minimum unobstructed	1500mm minimum	
Landing with between 90º and 180º change of direction		1540 mm minimum unobstructed	2070mm minimum	

Source: Adapted from Table C1 Summary of specifications for walkways, ramps and landings, Australian Standard AS1428.1.

Handrails

According to AS 1428.1-2009, handrails should be installed on each side of the ramp. In residential applications though, where the future addition of handrails is possible, handrails on one or even both sides of the ramp could be omitted. For example, when a ramp is intended for use by a wheelchair pushed by a carer, or when one of the two sides of the ramp is a wall, handrails might not be needed. However, some type of protection, such as a projecting surface, for ramps and landings with dropoffs is recommended (Barnes, 1991).

Camber/Crossfall

A ramp camber or a crossfall on the landings serves as a drainage gradient, so that water can run off the ramp surface. By removing water from the ramp surface, the slipping hazard is reduced and the ramp material is better maintained. The maximum gradient of the camber or crossfall of all other landings should be 1 in 40, while the gradient in bitumen landings can be up to 1 in 33, according to AS 1428.1. The ramp run itself should not have a camber or crossfall.

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Landings at doorways should be level and not have a camber or crossfall. Landings that serve as turning spaces for wheelchairs shouldn't have much camber, because that could lead to stability issues.

Maintenance

The maintenance of a ramp depends on its material and on the environment where it is installed/constructed. Generally, ramps should be maintained and cleaned frequently, in order to be safe and keep the slip resistance characteristics of the floor material. If a ramp material requires more frequent maintenance than the tenant/owner can provide, the maintenance should be done by a family member, friend or carer or by a contractor.

Maintenance is related to the stability and safe use of ramps. For example, aluminium and wooden ramps have screws and bolts that can get loose, causing the ramp to be unstable or even collapse. Maintenance should occur at this point and the loose parts should be tightened to ensure the stability and durability of the ramp. Also, extensive use can cause parts of aluminium ramps to bend. These parts should be replaced as soon as possible, to ensure safety while traversing the ramp.

Accumulation of water, snow and leaves on a ramp can make the surface very slippery. Also, dampness could cause a wooden or metal ramp to rot or corrode. Water, ice and leaves should be removed from the ramp surface as soon as possible. Wooden structures should be sealed to delay rotting.

A concern for ramps that are placed on soil is that they might settle. Settling might lead to uneven transitions from the ramp to the door landing and the opposite, which could cause tripping. Maintenance can raise the ramp to its initial position, by reinforcing the soil below the ramp foundations.

Other elements that should be maintained are grip coatings/additives for timber, as well as grit strips, usually put on the ramp surface to increase its slip resistance. These get worn with use and should be reapplied or replaced.

High-profiled and very rough materials can be very slip resistant, but they can also be difficult to clean, as particles can be trapped in the holes or on the rough surface. Ramp manufacturers and/or installers can usually provide advise on how to effectively clean a ramp made from rough materials.

If the frequency of maintenance is an issue, users with mobility impairments should consider installing a lift instead (see Consumer Factsheet: Ramps or lifts for residential properties: comparing their costs and benefits and Summary Bulletin: Legalities of the Australian Standards and alternative access solutions to ramping, for more information).

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Environmental, aesthetic and/or social parameters

In the case of home modifications, ramps are usually installed on the exterior of houses, to provide a stair-free access to the interior. An exterior ramp should preferably be integrated to the environment, be aesthetically acceptable and harmoniously blending with the building's architectural style (Steinfield & Maisel, 2012). One way of having a ramp without a negative aesthetic impact is when it is designed as a landscape element. When treated as landscape elements, ramps consist of materials that are also included in the building fabric, they are surrounded by plants, trees or water elements, they are combined with residential type canopies, light bollards, railings, etc.

Image 1. A shallow ramp connects the parking with the house entrance through flower beds

Even though the front entrance of properties is the obvious place for building a ramp, the construction on a back entrance or garage could be advantageous. It could also provide direct access from the car to the house, potentially more space that might lead to shallower slope, protection from the weather and smaller aesthetic impact. Usually ramps not seen from the road are preferred because they provide privacy, don't have an impact on the aesthetics (institutional appearance which reinforces social stigma) and the value of the house and actually reduce the risk of intrusions, as it is not apparent that a person with reduced mobility is living in the property (Canada Mortgage and Housing Corporation, Accessible Housing by Design: Ramps). However, ramps shouldn't be constructed or installed on isolated areas of the property, both for safety issues and because users shouldn't need to travel long distances for approaching the ramp.

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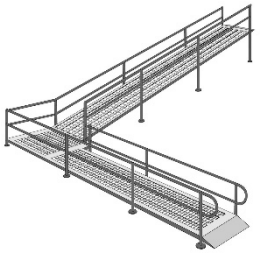
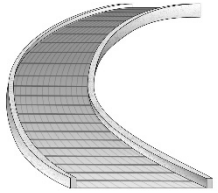
Table 4. Comparison of ramp geometries

Ramp Geometry	Advantages and disadvantages	Examples
Straight ramps	✓ Easier for wheelchair and scooter users to traverse (no turns) ✓ Less expensive × Require a long space × Hard to traverse when it is too long and without landings	
Ramps with switchbacks & Ramps with turns	✓ Smaller (not as long) space required ✓ The landing(s) provide resting × Non-standard wheelchairs might face difficulties turning × Require a wider space × Usually more expensive than straight ramps	
Curved ramps	✓ Require smaller space ✓ Usually they follow (go around) an architectural element (i.e. curved wall) × The cross section of the run will probably be leaning towards the centre of the circle, making the ramp dangerous or difficult to traverse × More expensive	

✓ Advantages × Disadvantages

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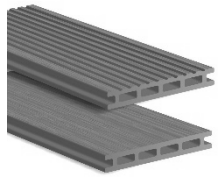
Table 5. Comparison of ramp materials

Ramp material	Advantages and disadvantages	Examples
Timber	✓ It can be slip resistant by adding special finishes ✓ Usually cheaper than iron, steel and concrete ✓ Average strength ✓ Aesthetically acceptable for residential buildings × Soft material, it might gouge, splinter, warp and fade if not properly maintained × Longer time of construction compared to temporary ramps × The cost increases when the length of construction and maintenance are considered	
Composite timber	✓ Resistant to rot and insect infestation ✓ Reduced installation time compared to timber ✓ Does not gouge, splinter, warp and fade- needs less maintenance than wood ✓ The slip resistance is a property of the material and there is no need to paint or stain × More expensive than (cheap) timber × The cheaper versions do not have the warm appearance of wood	

✓ Advantages × Disadvantages

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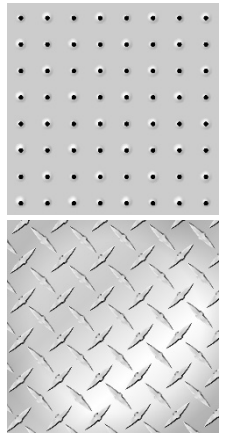
Aluminium	✓ It can be slip resistant when the floor surface is profiled ✓ Cheaper than steel and concrete ✓ Average/High strength ✓ Corrosion resistant ✓ Shorter construction time ✓ Requires less maintenance × Enhances the institutional appearance of the building × Not comfortable for barefoot walking when exposed to exterior conditions (solar radiation or rain)	
Concrete	✓ It can be very slip resistant when the floor surface is wood floated, broom finished or with exposed aggregate ✓ Average/High strength (for solid constructions, supported on the ground) ✓ Requires less maintenance ✓ Can be designed to blend with the landscape or the style of the building × Cracking and spalling can occur from the expansion of the reinforcement steel (when exposed to air and/or water, in environments where the temperature is changing quickly). × Construction of concrete ramps can be expensive	

✓ Advantages × Disadvantages

Source: https://upsideinnovations.com/best-ada-ramp-material

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Appendix 1: Slip Resistance of floor materials for sloping surfaces

Appendix 1 includes floor materials that are acceptable for sloping surfaces in residential environments, according to the New Zealand Building Code and is given as a practical guide. It is advisory and not adopted by Australian Standards, Guidelines or HMinfo. Please note that people may slip even on slip resistant level or sloping surfaces, because of other factors, like inappropriate use and footwear or unusual gait.

Floor surface material[10]	Dry sloping surface[1]	Wet sloping surface[1]
Timber		
Uncoated smooth	No	NO
Uncoated profiled[2]		
across profile	Yes	TEST
along profile	No	NO
Coated (paint, polyurethane etc.)	No	No
Coated and sand/grit impregnated[3]	Yes	Yes
Portland Cement concrete		
Smooth trowelled finish (class 3)[4]	Yes	NO
Broomed finish Class 5/6 [4] or wood float (U2)	Yes	Yes
Coated (paint, polyurethane etc.)	No	NO
Coated and sand/grit impregnated[3]	Yes	Yes
Exposed aggregate finish		
rounded aggregate	Yes	TEST
crushed aggregate	Yes	Yes
Asphaltic concrete	Yes	Yes
Marble and Granite		
Polished surface[5]	No	NO
Honed finish[6]	Yes	TEST

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Floor surface material[10]	Dry sloping surface[1]	Wet sloping surface[1]
Flamed finish	Yes	Yes
Fully sandblasted surface[6]	Yes	TEST
Patterned sandblasted surface	Yes	TEST[7]
Split slate	Yes	TEST
Terrazzo		
Polished	No	NO
Honed	Yes	TEST
Sandstone	Yes	TEST
Ceramic tiles Unglazed		
smooth finish	Yes	TEST
profiled	Yes	TEST[7]
grit finish	Yes	TEST[9]
Glazed		
smooth or polished finish[5]	No	No
profiled	Yes	TEST[7]
grit finish	Yes	TEST[8]
Clay pavers		
Wire cut	Yes	TEST
Smooth texture	Yes	TEST
Concrete Pavers		
Dry press concrete	Yes	TEST
Interlocking concrete block paving[9]	Yes	TEST
Moulded surface (e.g. simulated slate etc)	Yes	TEST

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Floor surface material[10]	Dry sloping surface[1]	Wet sloping surface[1]
Compressed fibre-cement sheet		
Uncoated	Yes	TEST
Coated (paint, polyurethane etc.)	No	NO
Coated and sand impregnated[3]	Yes	Yes
Rubber tiles / sheeting		
Smooth	Yes	TEST
Profiled	Yes	TEST[7]
Vinyl and Linoleum		
Smooth with imprinted pattern	Yes	NO
Profiled (studs or ribs)	Yes	TEST[7]
Grit/flaked finish	Yes	TEST
Carpet		
Tufted or looped pile[11]	Yes	Yes
Artificial turf[11]	Yes	Yes
Timber composites (e.g. chipboard, cork tiles etc.)		
Uncoated	Yes	NO
Coated (paint, polyurethane etc.)	No	NO
Coated and sand/grit impregnated[3]	Yes	Yes
Anti-slip tapes[12]	Yes	TEST

Yes: Floor surface material of acceptable slip resistance. **No**: Floor surface material of unacceptable slip resistance. **TEST**: tests need to be conducted.

Source: Adapted from Table 2. Slip Resistance for Walking Surfaces (pg. 22) New Zealand Building Code, Clause D1: Access Routes (2016). New Zealand Ministry of Business, Innovation and Employment.

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Notes:

[1] Sloping surfaces with slopes greater than 1:50 but less than 1:10 for wet conditions, or less than 1:8 for dry conditions.
[2] Profile at right angles to direction of pedestrian traffic. Algal growth on uncoated timber walkways significantly reduces slip resistance when wet and requires regular removal, e.g. by high pressure waterblasting.
[3] The sand/grit, which is sprinkled over the complete surface of the final paint coating, should be a hard angular material, such as silica sand or calcined bauxite. The particle size should not be less than 0.2 mm, so that it is not submerged by the coating and not greater than about 2 – 3 mm, so that it remains tightly bound to the surface. If overpainted, testing is required to establish acceptability of slip resistance.
[4] Concrete surface finishes complying with NZS 3114.
[5] Glazed or polished surfaces are unsuitable in either wet or dry conditions for sloping surfaces or for stairs, even though test measurements may indicate adequacy, because of the effect of foot placement. Note also that when tested in the dry, very smooth surfaces can give anomalous high readings arising from slip-suction effects between the test slider and the test surface.
[6] The coefficient of friction can vary significantly with the extent of surface preparation.
[7] It is noted in AS/NZS 3661.1 that the slip resistance tests prescribed in that Standard may not be suitable for heavily profiled (or patterned) surfaces. The Standard references other tests which may be more suitable for such surfaces.
[8] When the grit finish has a “feel” rougher than 80 grit sandpaper, the surface may be deemed to have acceptable wet slip resistance, for either level or sloping surfaces or for stair treads, without testing.
[9] Interlocking concrete block paving to NZS 3116.
[10] To meet durability requirements of NZBC B2, the surface should have at least a five year life under normal maintenance.
[11] Validity of the listed typical values for coefficient of friction is uncertain as the test methods may not be applicable to carpets.
[12] Anti-slip tapes will normally require regular replacement to remain effective. To ensure foot contact, tapes should be placed at right angles to the line of travel and be spaced at no more than 150 mm centres.

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Appendix 2: Glossary

Accessible	Having features to enable use by people with a disability. (*AS 1428.1-2009*)
Accessway	A continuous accessible path of travel to, into or within a building. *(National Construction Code 2016)*
(Ramp) Camber	Curved cross section of ramp or pathway with raised centre which sheds surface water to either side of the path (https://www.pathsforall.org.uk/pfa-home).
Circulation Space	A clear unobstructed area, to enable persons using mobility aids to manoeuvre (AS 1428.1-2009, pg. 7)
Class 1a Building	A free-standing (detached) or attached single dwelling that does not have another dwelling above or below. Dwelling types can include houses, semi-detached houses, townhouses, terrace houses and villas.
Class 1b Building	A free-standing (detached) or attached dwelling, not exceeding 300 m^2 floor area or having more than 12 residents, that does not have another dwelling above or below. Dwelling types can include small boarding houses and hostels.
Class 2 Building	A residential building of two or more storeys, containing two or more dwellings. Dwelling types can include apartments, units, flats, and duplexes.
Class 3 Building	A residential building (not Class 1 or 2) for numerous unrelated people to live in the short-term or long term. Dwelling types can include boarding houses and hostels, residential dwellings in hotels, motels, healthcare buildings and schools, and specialised accommodation the aged, children, and people with disability.
Continuous accessible path of travel	An uninterrupted path of travel to, into or within a building providing access to all accessible facilities. (AS 1428.1-2009, 4.6)
(Ramp) Crossfall	A crossfall is a gradient across the path (ramp) surface which allows water to flow towards the lower path edge. (https://www.pathsforall.org.uk/pfa-home)
Guide dog	A working dog that has been trained to safely guide people with vision impairments or guide and/or help people with mobility impairments.
Handrail	A rail used in circulation areas such as corridors, passageways, ramps and stairways to assist in continuous movement.
Kerb Ramp	An inclined surface on a continuous accessible path of travel with a maximum rise of 190 mm, a length not greater than 1520 mm and a gradient not steeper than 1 in 8, located within or attached to a kerb (*AS 1428.1-2009*)
Ramp	An inclined surface on a continuous accessible path of travel between two landings with a gradient steeper than 1 in 20 but not steeper than 1 in 14. (*AS 1428.1-2009*)
Fall	An “event which results in a person coming to rest inadvertently on the ground or floor or on another lower level” (World Health Organization (2005) cited in Ozanne-Smith, Guy, Kelly, & Clapperton, 2008)

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NCC	National Construction Code 2016
Slip resistance	Frictional force opposing movement of an object across a surface, usually with reference to the sole or heel of a shoe on a pedestrian surface. *(AS 4586-2013)*
Slip resistant (Slip resistive)	Property of a pedestrian surface where the available friction is sufficient to enable a person to traverse that surface without an unreasonable risk of slipping. *(AS 4586-2013)*
Step Ramp	An inclined surface on a continuous accessible path of travel with a maximum rise of 190 mm, a length not greater than 1900 mm and a gradient not steeper than 1 in 10 (*AS 1428.1-2009*)
Tactile ground surface indicator (TGSI)	Truncated cones and/or bars installed on the ground or floor surface designed to provide pedestrians who are blind or vision-impaired with warning or directional orientation information. *(AS 1428.4.1-2009)*

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Appendix 3: Regulatory Requirements for Ramps

The legislation dealing with the regulation of the building activity in every state and territory in Australia is governed by a building Act. For example, in New South Wales building construction, standards and maintenance of building features are governed by the Building Act of 1989.

Building Acts inform the Building Regulations. The Regulations prescribe requirements and standards relating to the construction, use and maintenance of buildings. The National Construction Code (NCC) is adopted by and forms part of the Building Regulations and is used by the legislation to prescribe technical requirements that need to be satisfied when undertaking building work.

National and/or International Standards related to building systems and services are voluntary documents that set out detailed specifications and guidelines and are often referenced by the NCC. When Australian Standards® (AS) are referenced in legislation the compliance with their requirements becomes mandatory.

National Construction Code 2016, Volume 1

The National Construction Code (NCC) includes the Building Code of Australia (BCA - Volumes One and Two) and the Plumbing Code of Australia (Volume Three).

The 1st volume of the National Construction Code (NCC), includes provisions for the accessibility of people with disabilities for class 2-9 and 1a buildings, requires that all ramps used for the accessibility of people with disabilities should have slip resistant surfaces and suitable handrails and landings, where appropriate. Generally, NCC refers to AS 1428.1 for requirements for ramps. In Clause D3.8, NCC Volume 1 requires the provision of tactile ground surface indicators to indicate the position of a ramp and make it safe for people with vision impairments.

AS 1428.1-2009

Design for access and mobility, Part 1: General requirements for access- New building works

Australian Standard AS1428.1, is the Standard giving the most detailed provisions for safe and accessible ramps. A ramp is defined in this Standard as:

“An inclined surface on a continuous accessible path of travel between two landings with a gradient steeper than 1 in 20 but not steeper than 1 in 14”.

A gradient 1 in 20, means that for every metre rise of the ramp, a 20-metre ramp length is required.

Ramps that have lengths smaller than 1900mm, however, could be steeper, as they constitute special types of ramps, used for ascending/descending small changes in level. For example, a kerb ramp is a ramp with a maximum rise of 190mm, a length no greater than 1520mm and a gradient not steeper than 1 in 8, located within or attached

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to a kerb. A step ramp has a maximum rise of 190mm, a length not greater than 1900mm and a gradient not steeper than 1 in 10. A ramp threshold has a maximum rise of 35mm, length not greater than 280mm and a gradient not steeper than 1 in 8.

Other documents that provide information related to ramps or one of their main elements, are:

AS 4586-2013

Slip resistance classification of new pedestrian surface materials

AS 4586-2013 gives the slip resistance classifications for walkways' surfaces and the testing methods for acquiring these classifications.

AS 4663-2013

Slip resistance measurement of existing pedestrian surfaces

Guidance for the in-situ testing of the slip resistance of pedestrian surfaces.

HB 197-1999

An introductory guide to the slip resistance of pedestrian surface materials

This handbook provides assistance with specifying pedestrian surface materials for various locations.

HB 198-2014

Guide to the specification and testing of slip resistance of pedestrian surfaces

Guidance on the appropriate slip resistance in common applications.

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Checklist for Ramps

USERS

- ☐ Who will be the users of the ramp (residents, visitors and carers), and how their abilities could affect the ramp design (gradient, width, slip resistance of surface, etc)
- ☐ What is the weight of the users that need to traverse the ramp at the same time
- ☐ What will the frequency of use of the ramp be
- ☐ What type of footwear is likely to be worn while traversing the ramp and whether it would be used barefoot
- ☐ Which are the characteristics of a ramp that the main ramp user finds comfortable traversing (ex. gradient easy to ascend, floor surface that makes him feel safe, grabrails, etc)
- ☐ Are the abilities of the users likely to change in the future and if yes, how?

ENVIRONMENT

- ☐ Is there enough space for a ramp that the users will use comfortably
- ☐ Where will the ramp be installed/constructed: indoors or outdoors
- ☐ Is the ramp surface likely to get wet from rain
- ☐ If yes, can a canopy be constructed
- ☐ What is the surface on which the ramp will be supported/built like
- ☐ Which of the materials of the exterior of the house or of the garden elements could potentially be used for the ramp structure
- ☐ Is there enough space for landings at the beginning and end of the ramp
- ☐ Is there enough electric light where the ramp is going to be installed
- ☐ Could a platform lift or stair lift be an alternative solution

RAMP SURFACE

Does the ramp surface supplier provide information on:

- ☐ The slip resistance classification for the floor surface, with test report available
- ☐ The durability of the floor surface for the location where it will be used
- ☐ The method and frequency of cleaning required for the surface
- ☐ The ongoing longer term maintenance (such as coating) to keep the ramp surface slip-resistant
- ☐ Can residents undertake the required cleaning and maintenance of the ramp surface and structure, currently and in the future?

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