BRANZ

ISSUE 625 BULLETIN

STAIR DESIGN

August 2018

- Considering stair location and design at the start of a project is essential for the safety of the people using the stairs.
- Stairs must have uniform treads and risers, visually identifiable leading edges or nosings and handrails fixed at the correct height and location.
- This bulletin updates and replaces Bulletin 495 of the same name.

1 INTRODUCTION

1.0.1 Statistics identify that falls on steps and stairs are a significant cause of serious injury in New Zealand. The majority of falls occur while people are descending stairs, with the most at-risk age groups being children under 5 and the elderly.

1.0.2 Stair design and location must be considered at the initial design stages to ensure sufficient space is allowed for the stairs to be installed and functional.

1.0.3 Good stair design is essential for the safety of people using the stairs. Stair design is incorporated in the Building Act and New Zealand Building Code clause D1 *Access routes*.

1.0.4 Clause D1 states that people must be safeguarded from injury during movement into, within and out of buildings. Acceptable Solution D1/AS1 includes specific stair design information and slip-resistance requirements to meet the requirements of clause D1.

1.0.5 This bulletin sets out design requirements for stairs in accordance with D1/AS1. It also describes how stair dimensions are calculated and describes specific requirements for external timber stairs. It updates and replaces Bulletin 495 of the same name

2 TYPES OF STAIRWAYS

2.0.1 D1/AS1 defines a stairway as a series of internal or external steps or stairs with or without landings and including all necessary handrails to provide access between different levels. It defines six different types of stairways based on location and use:

- An **accessible stairway** must be able to be used by people with disabilities. Under the Building Code, a building required to be accessible must have at least one accessible stairway on the accessible route regardless of whether the building has a lift. Buildings exempt from accessibility requirements are housing (excluding public areas of housing developments) and some small industrial premises.
- A **common stairway** is for use by the public but does not need to be designed for people with disabilities.
- A **private stairway** is intended to be used by the occupants of a single household unit. There are three categories of private stairway:
  - A **main private stairway** provides access between the main living areas of a dwelling and may be used by people who are not resident in the dwelling. The category includes all exterior private stairways of a single household.
  - A **secondary private stairway** provides access to another floor that contains bedrooms, bathroom or other private spaces and is not expected to be used by people who do not live in the dwelling.
  - A **minor private stairway** provides infrequent access to a single space (such as a bedroom) and is not likely to be used by people who do not live in the dwelling.
- A **service stairway** provides access to the service areas of a building and will only be used by service personnel occasionally and is not intended for public access.

3 DESIGN CRITERIA

3.0.1 D1/AS1 defines the type, location and minimum design criteria for stairways, including:

- riser and tread dimensions and pitch line
- projections/nosings
- stairway width
- landing requirements
- curved and spiral stairways
- stair winders
- visibility on stairways
- handrails
- door openings onto stairways.

3.0.2 General 'good' design requirements for stairways include that they must:

- be uniform within the design limits set by D1/AS1 for the stairway type
- incorporate, especially for stairs in public buildings and public areas, visually defined treads and nosings – visual nosings are required on all accessible stairs and common stairs with open risers
- be well lit both during the day and at night
- have handrails of appropriate proportions and at the correct height and location for secure grip
- be free of obstructions or distractions
- have adequate headroom – 2000 mm is specified as a minimum in D1/AS1, although 2100 mm is considered comfortable for users
- have adequately sized landings.

3.1 RISER AND TREAD DIMENSIONS AND PITCH LINE

3.1.1 Most accidents occur as people are going down stairs. Shallow tread depth and poor tread edge or nosing definition are significant causes of falls. When a person goes down stairs, they generally have their weight slightly forward. The ball of the foot contacts the front edge of the tread while the heel seldom lands fully on the tread. Tread depth is critical for a safe descent. A shallow tread depth means the foot landing will be closer to the front of the tread and there is more likelihood of overstepping.

3.1.2 D1/AS1 Table 6 and Figure 11 set out minimum tread depths and maximum riser heights based on the stair type. Tread depths range between 220 and 310 mm and riser heights between 180 and 220 mm (Table 1).

3.1.3 The ratio of tread depth to riser height determines a stairway's steepness or pitch (Figure 1). A pitch that is too low can be difficult to negotiate because it prevents a person developing a comfortable gait. D1/AS1 therefore recommends a minimum pitch of 23°.

3.1.4 Tread and riser dimensions in a stairway must be uniform. Even very small variations in riser height can cause a person to stumble, and irregular tread depths make it difficult to judge the leading edges of treads. Under D1/AS1, a maximum variation of riser height and tread depth of ±5 mm is permitted. This must be measured at the centreline for straight flight stairs and at the pitch line on curved, spiral and winder stairs.

3.2 TREAD PROJECTIONS/NOSINGS

3.2.1 Tread projections/nosings at the leading edges

Table 1. Stair design factors.

Stairway type	Maximum pitch	Maximum riser height (mm)*	Minimum tread depth (mm)*	Nosing radius (mm)	Open stair permitted
Accessible	32°	180	310	5–10	No
Common and main private	37°	190	280	N/A	Some situations
Secondary private	41°	200	250	N/A	Yes
Service and minor private	47°	220	220	N/A	Yes

* The old rule of thumb of 2 risers + 1 tread = 580–610 mm should not be used.

of stairs can allow an increase in the depth of the stair tread. D1/AS1 allows:

- closed stairs to have no projection or up to a maximum of 25 mm
- open risers (where unavoidable) to have at least 15 mm projection up to a maximum of 25 mm.

3.3 SLIP RESISTANCE OF TREADS

3.3.1 All stair treads must have sufficient slip resistance for their in-use condition. D1/AS1 Table 2 identifies the materials with acceptable slip-resistant finishes and the materials and finishes that may not be used for stair treads. For commercial installations, proprietary colour-contrasted nosing strips are available, which should be non-slip and installed with the top surface flush with the tread surface. Carpet on domestic stairs will provide sufficient slip resistance but a gloss polyurethane finish will not.

3.4 OPEN RISERS

3.4.1 Open risers are not permitted for accessible stairways. They can be visually distracting and difficult for people with disabilities to use as they often use the solid riser to guide the foot to the next tread. Open risers may be used for common stairways but only if there is also an accessible stairway to provide alternative access. The leading edges of the treads must also be colour-contrasted with the rest of the tread.

3.4.2 Where children under 6 may frequent a stairway (typically stairs within a dwelling unit) , open risers must not allow a 100 mm diameter sphere to pass between the treads.

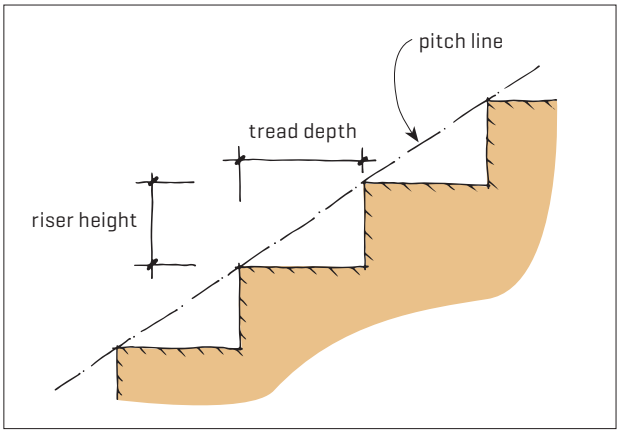


Figure 1. Pitch line.

3.5 STAIR WIDTH

3.5.1 The width between handrails for an accessible stairway or between a handrail and wall on a common stairway must be at least 900 mm. D1/AS1 does not set a minimum width for stairs in household units but recommends a practical minimum width of 850 mm. This is based on Acceptable Solution C/AS2 to clause C *Protection from fire* paragraph 3.3.2 for risk group SM (multi-unit dwellings).

3.6 STAIRWAY PLAN SHAPE

3.6.1 The plan of the stairway can influence the stair's safety. A straight stairway gives a clear view of the entire flight. Quarter-landing and half-landing (dog-leg) stairways with short flights and landings at changes in direction also have a clear view for each section or length and are limited in height.

3.7 CURVED, WINDER AND SPIRAL STAIRWAYS

3.7.1 Stairways with winders or tapered treads are generally more compact in area and often provide the only solution for fitting a stairway into a limited space (Figure 2).

3.7.2 Under D1/AS1, curved, winder and spiral stairways 1.0 m wide are permitted for private and service stairways. Curved stairways more than 1.0 m wide are permitted as accessible stairways if handrails are installed on both sides of the stairs.

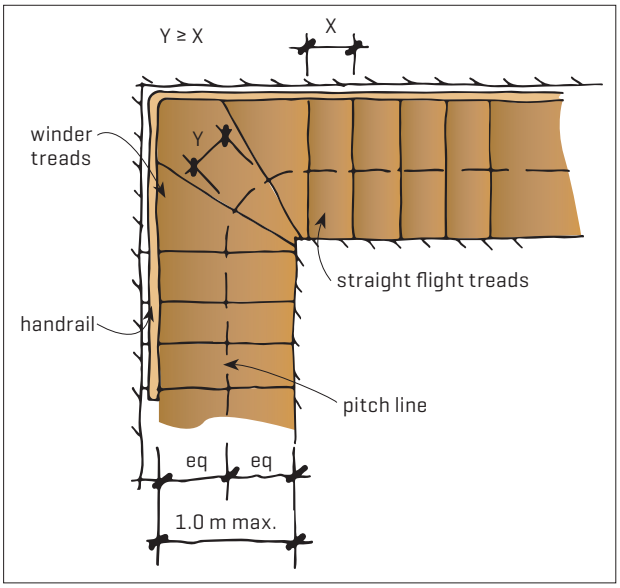


Figure 2. Stairway with winder.

3.7.3 For a curved stairway width of less than 1.0 m, the pitch line shall be located 300 mm from the handrail on the outside of the curve (Figure 3a). For curved stairs of 1.0 m in width or more, the pitch line shall be located 300 mm from the inside handrail of the stairway (Figure 3b).

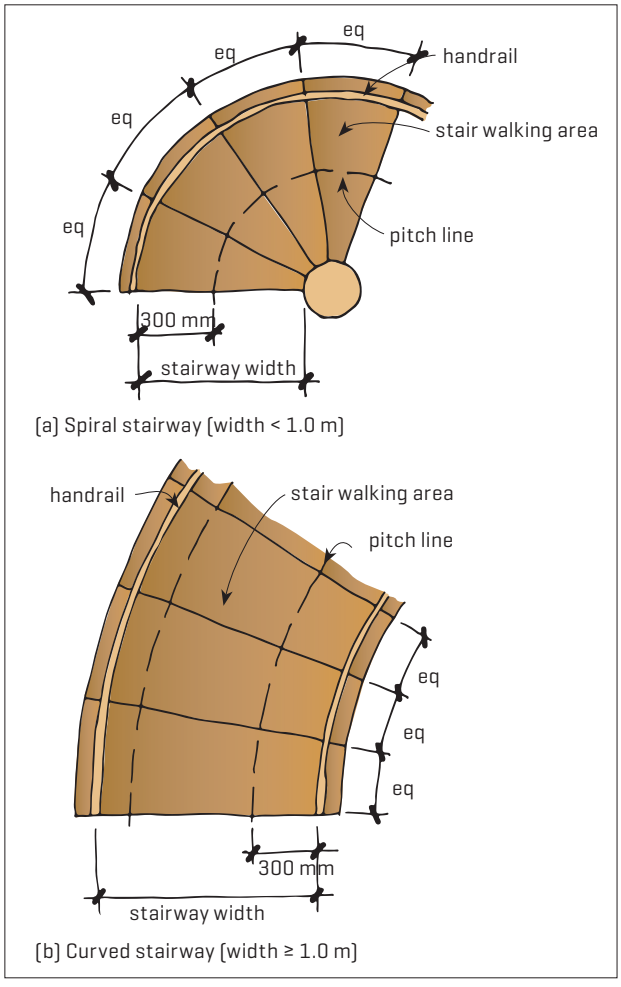
3.7.4 Other requirements include:

- riser height and tread depth is measured at the pitch line and must comply with the other requirements of D1/AS1 Table 6 and Figure 11 (Figure 3 below)
- riser height and tread depth at the pitch line are the same as the adjoining stairs
- winders must have a uniform taper
- consecutive winders must not turn through more than 180°.

3.7.5 For a winder stair, the walking or footfall zone is typically about 300 mm from the handrail, and treads in this zone should not exceed 420 mm in width. The pitch line is measured:

- 300 mm from the handrail (where the treads will be wider) when the stair is less than 1.0 m wide
- 300 mm from the inside curve of the stairway when the stair is more than 1.0 m wide.

3.7.6 Spiral stairways are typically no more economical in plan area than a straight or dog-leg stairway of equivalent rise. In addition to occupying approximately the same plan area per rise, there is also unused space around their circular shape. Spiral stairways are more hazardous as the narrowest part of the tread is generally well below the permitted minimum. An Acceptable Solution for spiral stairs having a diameter of no less than 1.5 m (where the requirements of D1/AS1 Figure 17 can't be met) is given in BS 5395-2:1984 *Stairs, ladders and walkways. Code of practice for the design of helical and spiral stairs.*



(a) Spiral stairway (width < 1.0 m)

(b) Curved stairway (width ≥ 1.0 m)

Figure 3. Pitch line on spiral and curved stairs.

3.8 LANDINGS

3.8.1 Where a door opens onto a stairway, a landing with sufficient space to stand while operating the door must be provided at the top and bottom of every flight of stairs.

3.8.2 The width of the landing must be at least the same width as the stairway and have a minimum length of 900 mm. For a dog-leg stairway, it is recommended that the landing is increased in size to assist when manoeuvring large furniture or objects.

3.9 NUMBER OF RISERS IN A FLIGHT

3.9.1 D1/AS1 limits the total rise in a flight between landings (Table 2).

Table 2. Permitted rise between landings.

Stairway type	Maximum rise (metres)
Accessible	2.5
Common	2.5
Private	4.0
Service	4.0

3.10 CIRCULATION SPACES

3.10.1 Stairways located off circulation spaces or corridors should be recessed at least 600 mm at the top and 750 mm at the bottom of the flight. This avoids pedestrian collisions and allows handrails to level out without encroaching into circulation routes.

3.10.2 Doors should not open directly onto a flight of stairs or into the traffic flow at the top or bottom of a stairway (Figure 4). A clear space of at least 400 mm across the full width of the landing must be provided beyond the arc of the door swing. The exception is where the rise is no more than 600 mm and the door opens away from the stairway or is a sliding door (D1/AS1 clause 4.3.5 and Figure 15).

3.11 HEAD HEIGHT CLEARANCE

3.11.1 People going down stairs should be able to do so without having to bend or duck. D1/AS1 requires a minimum height clearance for stairways and landings to be 2.0 m measured from the pitch line. If possible, provide at least 2.15 m to give more headroom.

4 HANDRAILS

4.0.1 Handrails provide support when ascending and descending stairways as well as a visual cue to the presence of a stairway.

4.0.2 Accessible stairways must have handrails on both sides. All other stairways that are less than 2.0 m wide

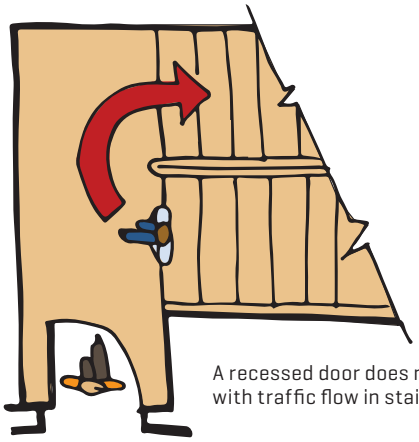


Figure 4. Doors near stairs.

and have two or more risers require at least one handrail. Stairways more than 2.0 m wide require handrails to both sides, and when the width is more than 4.0 m, a central handrail is also required. D1/AS1 does not require a handrail for a stair in a household unit with three risers or fewer although providing one is an added safety feature.

4.0.3 Handrails must be between 900 mm and 1.0 m high measured from the pitch line to the top of the handrail and have the same slope as the pitch line.

4.0.4 They must be continuous from the top to the bottom of each flight. For accessible stairways, handrails must extend 300 mm horizontally beyond the top nosing and the bottom riser to facilitate stairway use by people with visual or physical disabilities. The requirement for an extended handrail may affect the location of the first riser or the top tread of a stair.

4.0.5 The terminations of accessible handrails should be turned down at least 100 mm or returned into the wall to prevent a potential hazard (NZS 4121:2001 *Design for access and mobility: Buildings and associated facilities*). Where possible, handrails should be a contrasting colour from their surroundings.

4.0.6 Handrail profiles must be easy to grasp and be in accordance with dimensions shown in D1/AS1. They should be secure and fixed so a person's hand will not contact the wall, supporting brackets, fixings or any other obstructions. The optimum graspable handrail is a 40 mm diameter round profile.

5 SAFETY BARRIERS

5.0.1 Under Building Code clause F4 *Safety from falling*, a safety barrier must be provided where a fall of more than 1.0 m is possible.

5.0.2 Stair barriers must be able to withstand all imposed and impact loads (including wind loads for external stairs) without collapsing, becoming unstable or deflecting unreasonably. There is currently no Acceptable Solution for safety barrier design, so safety barriers generally require specific design. However, a Ministry of Business, Innovation and Employment (MBIE) Building and Housing Group publication *Guidance on barrier design* (clause 4.2.7) provides some design and installation guidance for safety barriers as referenced in MBIE *Codewords* 54.

5.0.3 Acceptable Solution F4/AS1 requires that safety barriers in areas frequented by children under 6 are constructed so that:

- a 100 mm diameter sphere cannot pass through openings in the barrier
- they are not climbable – that is, they do not generally have horizontal rails.

5.0.4 For stairs, the triangular openings between the tread, riser and bottom rail of the safety barrier must not allow a 150 mm diameter sphere to pass through.

6 LIGHTING

6.0.1 Lighting requirements based on stairway type are set out in D1/AS1 Table 8 and clause G8 *Artificial light*. Levels of lighting must provide at least 150 lux for accessible and common stairs and 100 lux for private and service stairs.

6.0.2 Switches for stair lighting must be able to be activated from the top and bottom of stairways and at any intermediate landings that have access to or from a floor level.

7 UNIVERSAL DESIGN

7.0.1 While section 3 covers the design requirements of D1/AS1, to ensure dwellings are easy to use for all, it is considered 'good' practice to consider at the design stage:

- a 23° pitch line (lower riser and increased tread)
- avoiding open treads
- using slip-resistant treads with contrasting nosings to all stairs
- good lighting
- a continuous graspable handrail with end terminations as described in section 4.0.5
- a glare-free environment
- a power outlet at the top or bottom of the stairway for a future stair lift.

8 SETTING OUT THE STAIR

8.0.1 Calculate dimensions for a stair as follows:

1. Determine the total rise – that is, floor-to-floor height (say 2500 mm).
2. Calculate the number of risers required by dividing the floor-to-floor height by the maximum permitted riser height for the stair type (say 190 mm for a common stairway). For example, 2500/190 = 13.16.
3. As the result is generally not a whole number, add one more riser. For example, 13 + 1 = 14 risers.
4. Divide the height between floors by the number of risers to calculate the actual riser height. For example, 2500/14 = 178.6 mm.
5. Stairs always have one more riser than treads so 14 risers requires 13 treads. The minimum permitted tread depth is 280 mm, but as there is ample space for the stairs in this example, 300 mm depth has been selected. It is better to work out the stair using the going dimension (overall run) and then selecting a tread width that fits.
6. Multiply the tread depth by the number of treads to calculate the overall length of the stair. For example, 300 x 13 = 3900 mm.
7. If a landing or change in direction is required, this dimension must be added to the overall length. Where

a change in direction of the stairway is required but there is insufficient space for a landing, a winder may need to be included.

8. If necessary, the stairway pitch can be determined from D1/AS1 Figure 11. Stairway pitch is sometimes useful for calculating an increase to the tread depth without adding to the overall plan length of the stairway (Figure 5). (Note that all three stairway pitches shown in Figure 5 are permitted for a common stair as they are all under 37°. If space is available, the 300 mm tread provides a longer and safer foot landing.)

9 EXTERNAL TIMBER STAIRS

9.0.1 External timber stairs and handrails are exposed to all weather conditions, including regular wetting and drying and exposure to high levels of UV light. Regular wetting and drying causes the timber to swell and shrink, while changes in ambient temperature cause expansion and contraction. The constant movement results in timber warping and cupping, joints opening up, nails popping and fixings becoming loose. Timber that remains wet for extended periods of time will become slippery and rot. This means that, in addition to the same design criteria required for interior stairs, external timber stairs have some specific requirements.

9.1 TIMBER TREATMENT

9.1.1 External stair timber generally should be graded SG8 (wet in use) radiata pine treated to hazard class H3.2 or be a timber species considered as naturally durable. Non-structural baluster or infill timber may be SG6 (No. 1 framing) H3.2 treated. Timber in ground contact must be H5 treated.

9.2 EXTERNAL TREADS, RISERS AND STRINGERS

9.2.1 Stringers are effectively beams spanning between the top and bottom of a flight of stairs. Dimensions for stair stringers are not included in NZS 3604:2011 *Timber-framed buildings* so BRANZ has calculated stringer sizes. Table 3 sets out the maximum spans for different stringer sizes.

Table 3. Maximum span for stringer sizes.

Stringer size (mm)	Maximum span (m)
290 x 45	4.0
240 x 45	3.3
190 x 45	2.6
140 x 45	1.9

9.2.2 Treads spanning 900–1000 mm between stringers should be a nominal 50 mm thick and be grooved or have a slip-resistant finish (Figure 6). Boards should have 5 mm gaps between them. Treads may be fixed to stringers:

- by being housed into a 13 mm rebate – housing treads into stringers for external treated timber stairs is not recommended, as it may compromise the timber treatment
- on timber or steel brackets/cleats (Figure 7)
- that have been cut to suit the tread and riser dimensions
- that are blocked to suit the tread and riser dimensions.

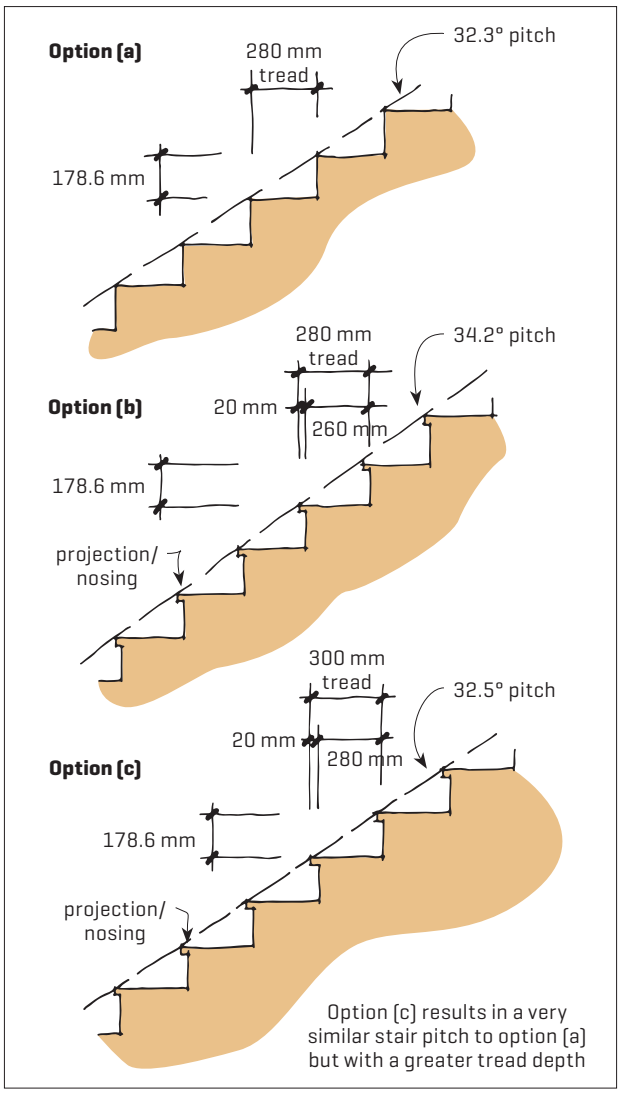


Figure 5. Calculating stair pitch and tread depth using D1/AS1 Figure 11.

9.2.3 For a wide stair, add a mid-span stringer for support (Figure 8). Although stairs up to 1.5 m wide may not require mid-span support, the addition of a central stringer will minimise sagging and deflection.

9.2.4 To stiffen stairs and stop the stringers from spreading, 12 mm diameter threaded rods spaced at 1.2 m maximum should be used to tie stringers together.

9.2.5 D1/AS1 allows a common stairway to have open risers as long as the gaps are not large enough for a 100 mm diameter sphere to pass through. Blocking (45 x 15 mm) may be required to ensure the gap is not too large (Figure 6). Open risers can be difficult for people with mobility impairments who are required to slide their feet/prosthetics up to the riser as well as for those with visual impairment.

9.3 SUPPORT FOR STRINGERS

9.3.1 Stringers may be fixed at the top to a boundary or edge joist using joist hangers and supported at the bottom with stainless steel post brackets or timber/concrete cleats on a concrete footing.

9.3.2 Concrete footings should be at least 200 mm square x 200 m deep with cast-in post brackets or bolts

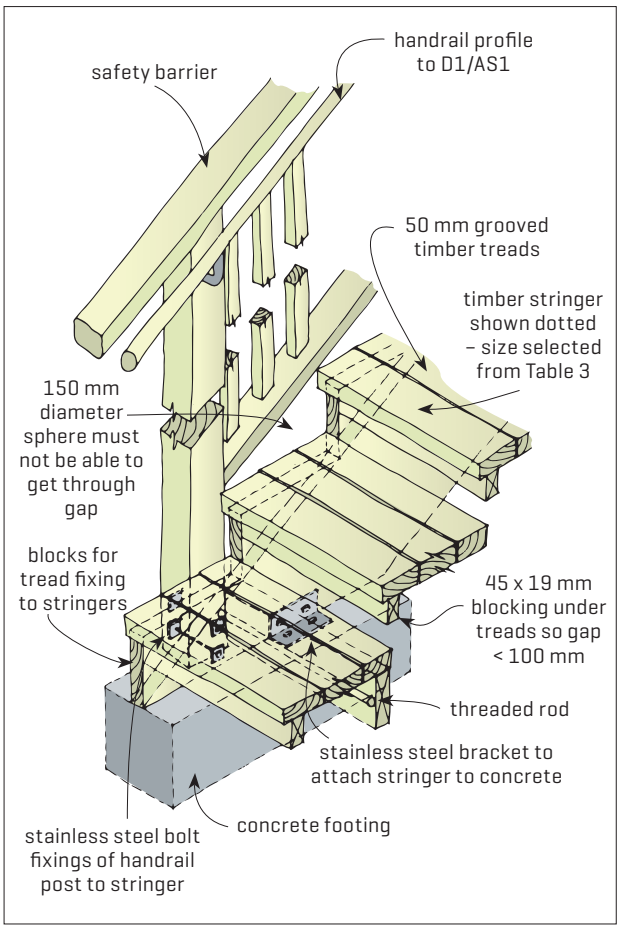


Figure 6. External open tread stair and handrail.

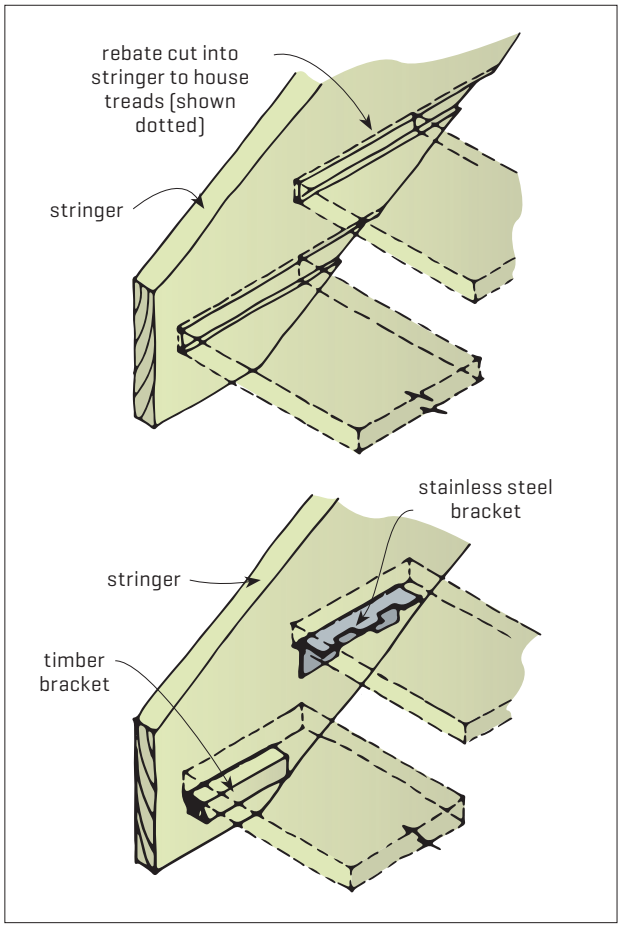


Figure 7. Tread fixing options.

for cleat fixing. Alternatively, stringers may be supported by being bolted to the timber posts using two M12 bolts per post, with the post set in minimum 200 mm square x 200 m deep concrete footings.

10 STAIR TERMINOLOGY

Flight – series of steps without a landing.

Going dimension – the distance between tread nosings.

Handrail – a rail that is at the same slope as the pitch line to provide support for people ascending or descending the stair. Handrails must be between 900 and 1000 mm (measure to the top of the handrail) above the pitch line.

Landing – a level platform at the top or bottom of a flight of stairs.

Nosing – the front edge of a step or stair tread, which projects beyond the riser.

Pitch line – the line joining the leading edge of successive stair treads in a single flight of stairs.

Riser – the vertical component of the step used to connect treads.

Stringer – the inclined timber member on each side of the stairs supporting treads and risers.

Tread – the horizontal surface of the step.

11 ADDITIONAL RESOURCES

New Zealand Building Code clauses

B1 *Structure*

B2 *Durability*

D1 *Access routes*

F1 *Safety from falling*

Standards New Zealand

NZS 3602:2003 *Timber and wood-based products for use in building*

NZS 3604:2011 *Timber-framed buildings*

NZS 4121:2001 *Design for access and mobility: Buildings and associated facilities*

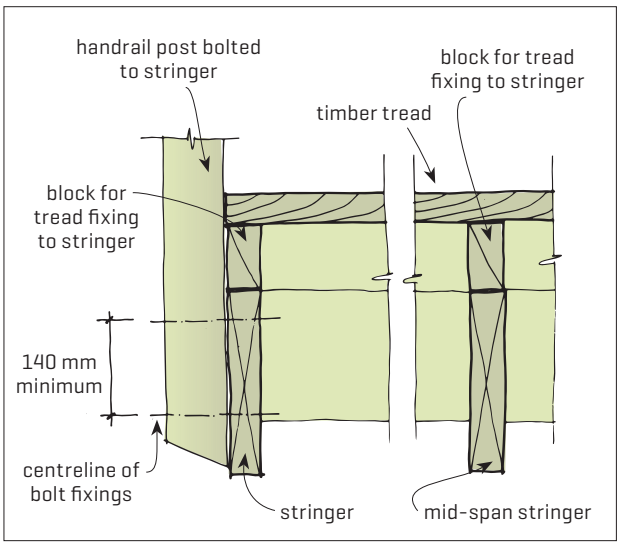


Figure 8. Section through stair tread and stringers.

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