

AS 2316.1.1:2021



# Artificial climbing structures and challenge courses

**Part 1.1: Safety requirements and test methods for belayed climbing and abseiling structures**



AS 2316.1.1:2021

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- Christian Venues Association
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- Outdoor Council of Australia
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# **Artificial climbing structures and challenge courses**

## **Part 1.1: Safety requirements and test methods for belayed climbing and abseiling structures**

Originated as AS 2316.1—2009.  
Revised and redesignated in part as AS 2316.1.1:2021.

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## Preface

This Standard was prepared by the Standards Australia Committee SF-047, Artificial Climbing Structures to supersede in part AS 2316.1—2009, *Artificial climbing structures and challenge courses, Part 1: Fixed and mobile artificial climbing and abseiling walls*.

The objective of this document is to provide designers, manufacturers, proprietors and operators with requirements and guidance specific to the design, construction, operation and maintenance of artificial climbing structures used for climbing and abseiling in order to maximize the protection of health and safety for both operators and users.

This document forms part of the AS 2316.1 series. The series will consist of the following three Parts:

AS 2316.1.1, *Artificial climbing structures and challenge courses, Part 1.1: Safety requirements and test methods for belayed artificial climbing and abseiling structures* (this document)

AS 2316.1.2, *Artificial climbing structures and challenge courses, Part 1.2: Safety requirements and test methods for bouldering structures*

AS 2316.1.3, *Artificial climbing structures and challenge courses, Part 1.3: Safety requirements and test methods for climbing holds*

The document acknowledges that in a variety of environments, residential/recreational camps, climbing gyms and schools, artificial climbing structures (ACSS) have a significant percentage of clients that bring their own equipment to perform the activities which requires maintenance and appropriate storage. Where this occurs, it introduces risk that is a shared responsibility for both the user and operator.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

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## Introduction

This document is concerned with the design, construction, testing and operation of artificial climbing and abseiling structures. Artificial climbing and abseiling structures originated from the desire to simulate the climbing and belaying challenges encountered in the recreational pursuit of rock climbing in a manner accessible to the general public. Climbing and abseiling solely on artificial structures is now considered to be a recreational pursuit in its own right, as well as being recognized internationally as a sport and as a valuable training or learning tool by education institutions and employers.

Climbing and abseiling, for many users, introduces stressors (e.g. height) to increase perceived and real personal risk, enabling people and teams to perform outside their “comfort zone” in order to maximize the recreational experience to develop their maximum potential. These challenges can be pivotal tools for training or learning outcomes such as developing self-confidence, trust, honesty, teamwork, responsibility, humility, fear management and loyalty. Climbing is not just about getting to the top of the structure. Much of climbing’s attraction can be attributed to the associated commitment elements, such as trust and responsibility.

Artificial climbing and abseiling structures can provide a training and recreational activity that, when compared to a similar activity in a natural setting (i.e. bushland) provide —

- (a) a more cost effective option;
- (b) a more controlled environment with more predictable hazards and risks;
- (c) local, easier and more frequent access, reducing transport costs;
- (d) on-site logistic and medical support;
- (e) a less abrasive environment to consumable equipment, maximizing the serviceable life of equipment;
- (f) flexibility of training and learning outcomes;
- (g) tailored learning simulations for workplace exercises such as team-building and corporate training; and
- (h) reduced environmental damage.

Use of an artificial climbing structure involves three activities — climbing, belaying and abseiling.

Climbing is the act of an individual, progressing (upwards, downwards or sideways) with or without assistance across the surface by holding or standing on natural or installed surface projections, indents or aids.

Belaying can be defined as affording a safeguard to a moving climber. A belay system is used to protect a falling or descending climber from a high velocity impact with the ground or another structure. Typically, this relies on a belayer managing a belay rope and belay device during the climber’s progress. Other methods of belay (protection) such as automatic belay systems can also be used.

Abseiling is an act of self-descent on a fixed rope (as opposed to being lowered by a belayer).

The risk associated with climbing without a means of protection (belay) is considered to be unacceptable, except for where the climber is said to be bouldering (refer to AS 2316.1.2, *Artificial climbing structures and challenge courses, Part 1.2: Safety requirements and test methods for bouldering structures*).

In an artificial setting, climbers typically support themselves during progress along the climbing route by using handholds and footholds. The holds may be integral to the structure or may be removable. Commonly, removable holds are used to allow changes to the nature and difficulty of the climbing route (refer to AS 2316.1.3, *Artificial climbing structures and challenge courses, Part 1.3: Safety requirements and test methods for climbing holds*).

This document acknowledges that many types of belay systems exist, and others are likely to be devised in the future. It is not the purpose of this document to specify which systems should or should not be used, but rather to define the minimum safety requirements of such systems.

The climber's and abseiler's reliance on themselves or another to be competent at belaying and the belayer's responsibility to be competent, is recognized by the industry to be an essential and expected component to climbing and abseiling.

Adequate and appropriate maintenance of facilities should be performed in a timely manner.

This document has been developed to ensure that all associated infrastructure and equipment meets nominated criteria.

Adherence to this document should limit harm to those involved in incidents that are associated with human error and prevent incidents associated with equipment or structure failure, i.e. provide a safer environment to pursue the activities of climbing, belaying or abseiling.

# Australian Standard®

## Artificial climbing structures and challenge courses

### Part 1.1: Safety requirements and test methods for belayed climbing and abseiling structures

#### Section 1 Scope and general

##### 1.1 Scope

###### 1.1.1 General

This document specifies the minimum requirements for the design, construction, operation, supervision levels, maintenance and testing of belayed artificial climbing structures (ACS) and abseiling structures and associated components.

###### 1.1.2 Inclusions

This document includes indoor and outdoor structures and facilities used for climbing and abseiling.

###### 1.1.3 Exclusions

This document excludes the following:

- (a) Bouldering (refer to AS 2316.1.2).
- (b) Climbing holds (refer to AS 2316.1.3).
- (c) Natural surfaces with artificial holds and/or belay points.
- (d) Playground equipment (refer to AS 4685).
- (e) Structures associated with bungy jumping activities (refer to AS/NZS 5848).
- (f) Theatrical and stunt work.
- (g) Mobile artificial climbing structures [refer to AS 3533 (series)].
- (h) Inflatable climbing structures.

##### 1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

NOTE Documents for informative purposes are listed in the Bibliography.

AS 1138, *Thimbles for wire rope*

AS 1170.4, *Structural design actions, Part 4: Earthquake actions in Australia*

AS 1353.1, *Flat synthetic-webbing slings, Part 1: Product specification*

AS 1657, *Fixed platforms, walkways, stairways and ladders — Design, construction and installation*

AS 2076, *Wire-rope grips for non-lifting applications*

AS 2316.2.1, *Artificial climbing structures and challenge courses, Part 2.1: Flying foxes and challenge ropes courses — Construction and safety requirements (EN 15567-1:2007, MOD)*

AS 2318, *Swivels for lifting applications*

AS 2319, *Rigging screws and turnbuckles*

AS 2321, *Short-link chain for lifting purposes*

AS 2741, *Shackles*

AS 3569, *Steel wire ropes — Product specification*

AS 3600, *Concrete structures*

AS 4100, *Steel structures*

AS 4142.3, *Fibre ropes, Part 3: Man-made fibre rope for static life rescue lines*

AS 4497.1, *Roundslings — Synthetic fibre, Part 1: Product specification*

AS/NZS 1170.0, *Structural design actions, Part 0: General principles*

AS/NZS 1170.1, *Structural design actions, Part 1: Permanent, imposed and other actions*

AS/NZS 1170.3, *Structural design actions, Part 3: Snow and ice actions*

AS/NZS 1664, *Aluminium structures (series)*

AS/NZS 1720, *Timber structures (series)*

AS/NZS 1891.4, *Industrial fall-arrest systems and devices, Part 4: Selection, use and maintenance*

AS/NZS 4676, *Structural design requirements for utility service poles*

AS ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

EN 341, *Personal fall protection equipment — Descender devices for rescue*

EN 358, *Personal protective equipment for work positioning and prevention of falls from a height — Belts for work positioning and restraint and work positioning lanyards*

EN 361, *Personal protective equipment against falls from a height — Full body harnesses*

EN 362, *Personal protective equipment against falls from a height — Connectors*

EN 813, *Personal fall protection equipment — Sit harnesses*

EN 892, *Mountaineering equipment — Dynamic mountaineering ropes — Safety requirements and test methods*

EN 1891, *Personal protective equipment for the prevention of falls from a height — Low stretch kernmantel ropes*

EN 12275, *Mountaineering equipment — Connectors — Safety requirements and test methods*

EN 12277, *Mountaineering equipment — Harnesses — Safety requirements and test methods*

ISO 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

ISO 10333-5, *Personal fall-arrest systems — Part 5: Connectors with self-closing and self-locking gates*

### **1.3 Terms and definitions**

For the purposes of this document, the following terms and definitions apply.

**1.3.1****abseiling**

descending an artificial climbing structure using ropes and descender friction devices under your own control

Note 1 to entry: This may be belayed or non-belayed.

**1.3.2****acceleration**

vector that specifies the time-derivative (rate of change) of velocity. Acceleration measurement is usually made with an accelerometer

**1.3.3****acceleration pulse**

non-oscillatory acceleration of a short duration

**1.3.4****accelerometer**

sensor that measures the acceleration for a specified axis and frequency range

**1.3.5****anchor**

any load bearing attachment on or about the ACS to which a climber's or abseiler's rope is attached directly or indirectly during their progress on the structure. The anchor may be fixed or movable. Four classes of anchors are defined: lead anchors, top-rope anchors, stance anchors and ground anchors. An anchor constructed to accommodate more than one rope is defined as a multiple anchor of that class. An anchor may comprise more than one element, in which case the elements are connected

**1.3.6****artificial climbing structure****ACS**

structure specifically built for the purpose of climbing or abseiling

**1.3.7****auto-belay system**

device that acts as a belay system (1.3.8) but which does not require human intervention and that provides for the safe retardation of the climber to a controlled rate of descent such that there is no hazardous impact with the ground

**1.3.8****belay system**

means by which the climber or abseiler is protected from an uncontrolled fall or descent. This may include a back-up of the primary belay system in some circumstances

**1.3.9****climbing route**

surface of the ACS on which a climber progresses including all the holds and belay anchors, commonly but not necessarily indicated by the presence of a top-rope anchor and rope

**1.3.10****competent person**

person who has acquired through training, qualifications or experience, or a combination of these, the knowledge and skills enabling that person to perform a specified task

Note 1 to entry: For guidance, refer to Australian Adventure Activity Standard at <https://australianaas.org.au>.

**1.3.11****critical fall height**

maximum free height of fall for which a surface provides an adequate level of impact attenuation

Note 1 to entry: The critical fall height is determined according to the lowest test result obtained, see Appendix D

**1.3.12****descender device**

device by means of which a person may, at a limited velocity, descend from a higher to a lower position either on their own or assisted by a second person

**1.3.13****free space**

space in, on or around the ACS that may be occupied by a climber using the ACS

**1.3.14*****G***

acceleration due to the earth's gravity at sea level

Note 1 to entry: *G* varies with the latitude and elevation of the observer.

Note 2 to entry: By international agreement, the value 9.80665 m/s<sup>2</sup> is the nominal international standard acceleration due to gravity.

**1.3.15*****G*<sub>max</sub>**

maximum acceleration experienced during the impact attenuation test ([1.3.21](#))

**1.3.16****ground anchor**

anchor at the base of the ACS used to anchor the belayer

**1.3.17****head injury criteria****HIC**

measure of impact severity that considers the duration over which the most critical section of the acceleration pulse persists as well as the peak level of that acceleration

**1.3.18****hold**

removable climbing component used for progression on an ACS including bigger three dimensional, structural attachment without additional panel insert or other means of hold fixation

**1.3.19****impact area**

surface that may be impacted by a climber falling from the ACS

Note 1 to entry: Persons falling from an ACS do not necessarily land directly underneath it. If a person falls while jumping or making a dynamic move, the person is more likely to fall slightly away from the ACS. The area underneath and around the ACS in which persons are likely to fall or over which they could swing (pendulum) is included in the impact area.

Note 2 to entry: The extent of the impact area will depend on the height and configuration of the ACS.

**1.3.20****impact attenuation system****IAS**

pad, floor mat, carpet and foam composite flooring system, foam filled bag, or another system that transforms the kinetic energy from falls into controlled acceleration/time transition to zero velocity during impact

**1.3.21****impact attenuation test**

one impact measurement carried out from a specified height of 1.5 m or a series of at least ten impact measurements carried out from a specified height of 1.5 m

**1.3.22****impact attenuation test position**

position on the impact attenuating system ([1.3.20](#)) to be tested, located perpendicularly below the centre of the headform (missile)

**1.3.23****impact height**

distance between the surface and the lowest boundary of the headform (missile)

**1.3.24****impact measurement**

determination of the HIC and  $G_{\max}$  values from the recorded acceleration of the headform (missile) falling from one impact height onto one test position of the specimen

**1.3.25****lead anchor**

anchor on the ACS that is clipped by a belayed climber during their ascent up the wall while lead climbing

**1.3.26****may**

indicates the existence of an option

**1.3.27****minimum breaking load**

magnitude of the load above which if failure occurs during load testing the structure may break

**1.3.28****multiple ground anchor system**

anchor or system at the base of the ACS used to anchor the belayers or self-belaying systems of more than one climber

**1.3.29****multiple top-rope anchor**

anchor system or device at the top of a climbing route or routes designed to take the ropes of several climbers at once

**1.3.30****nominal load**

maximum load that may be generated in normal use

**1.3.31****out of service**

not in use but still subject to environmental loadings, e.g. wind loads

**1.3.32****proof test load**

load applied to onsite components of the ACS for the purposes of testing good installation practice or current fitness for use

**1.3.33****route setter**

person who attaches a variety of holds ([1.3.18](#)) and volumes ([1.3.41](#)) creating a route on the ACS

**1.3.34****shall**

indicates a statement is mandatory

**1.3.35****should**

indicates a recommendation

**1.3.36****span**

part of a multiple top-rope anchor measured between two consecutive supports or attachments (see [Figure B.2](#))

**1.3.37****stance anchor**

anchor consisting of one or more elements at a position on the structure where a climber may stop, attach themselves and protect fellow climbers who can join them at that position before the climb is continued

**1.3.38****top-rope anchor system**

anchor device or system at the top of a climbing route designed to take the rope of one climber

**1.3.39****tri-axial accelerometer**

accelerometer used to measure the components of acceleration relative to three orthogonal spatial axes

**1.3.40****users**

paying and non-paying people who use this equipment, including personnel who maintain and operate

**1.3.41****volume**

removable three dimensional, structural attachment with panel insert or other means of hold fixation designed for temporary extension of the climbing surface

## Section 2 Design, construction and equipment requirements

### 2.1 Structural and other requirements

The ACS shall be designed to accommodate the most adverse combination of loading that will be applied according to the appropriate Australian Standards for structural components, in particular the following:

- (a) For structural design actions and stability analysis, AS/NZS 1170 (series).
- (b) For structural steel, AS 4100.
- (c) For concrete structures, AS 3600.
- (d) For aluminium structures, AS/NZS 1664 (series).
- (e) For timber structures, AS/NZS 1720 (series).
- (f) For poles, AS/NZS 4676.
- (g) For wire rope, AS 3569.
- (h) For chain, AS 2321.
- (i) For fittings used with wire rope, AS 1138, AS 2076, AS 2318, AS 2319 and AS 2741.
- (j) For synthetic fibre components, AS 1353.1 and AS 4497.1.
- (k) For access ways and platforms, AS 1657.
- (l) Where trees are to be used, AS 2316.2.1.

### 2.2 Determination of the strength and stability of an ACS

#### 2.2.1 General

Where possible, the strength and stability of an ACS and the fixings to any surrounding structure shall be determined by calculation, using the design loads in [Table 2.1](#), in accordance with [Clauses 2.2.2](#) and [2.2.3](#).

Where the elements cannot be determined by calculation, the strength and stability of the wall and components shall be determined by using the relevant minimum breaking loads in [Table 2.1](#) applied in accordance with [Appendix A](#).

In the assessment of strength and stability, the load of a falling user shall be applied at the point of connection to the ACS at the most unfavourable angle between  $\pm 12.5^\circ$  from the vertical axis.

A combination of design loads with the other relevant forces, e.g. mass of the ACS and forces due to climatic conditions shall be performed. Use these loads in a stability analysis in accordance with the requirements for combinations of loads and confirmation of limit states in AS/NZS 1170.0.

**Table 2.1 — Loads**

| Load type                                           | Nominal load for design<br>kN | Minimum breaking load<br>( <a href="#">Appendix A</a> )<br>kN | Proof test load<br>( <a href="#">Appendix B</a> )<br>kN |
|-----------------------------------------------------|-------------------------------|---------------------------------------------------------------|---------------------------------------------------------|
| Normal load of a user                               | 0.8                           | —                                                             | —                                                       |
| Load produced by falling climber on an anchor point | 6.6                           | 20                                                            | 8<br>(commissioning)                                    |
| Subsequent proof testing                            | 6.6                           | 20                                                            | 6.6                                                     |
| Surface integrity and hold insert load              | 2.5                           | 7.5                                                           | 2.5                                                     |

All anchor points, including lead anchors, shall be proof tested before initial use. Unless otherwise specified within the design documentation, a full visual inspection shall be completed every 12 months.

If any failure is recorded all anchors of the same type shall be proof tested and all failures rectified before being returned to use and actions recorded.

The entire structure shall be checked by a competent person. Where an ACS is modified or extended, the above calculation and/or proof testing process shall be applied to any new and existing elements. The above calculation and proof testing shall be applied to any new elements at 8 kN and for any existing elements at 6.6 kN.

## 2.2.2 Design and frequency of inspection

A competent person shall provide calculations and drawings.

These calculations and drawings shall include whether the ACS is freestanding or fixed to an existing structure. This shall include the type of fixing to be used.

Calculations and drawings shall include details for the anchorages in the ground or at height.

A competent person shall provide the frequency, method of inspection and/or testing at the time of design of the anchors for the suspension of user(s).

## 2.2.3 Determination of strength

### 2.2.3.1 General

The strength of all aspects of an ACS (resistance to failure due to excessive deformation or rupture), details of anchor points and their connections and load paths to basic structure and connection of the structure to buildings or the like shall be verified by calculation.

### 2.2.3.2 Loadings

Strength shall be assessed by limit states methodology and take into consideration the following actions:

- Permanent and self-weight in accordance with AS/NZS 1170.1.
- Working loads in use as specified in [Table 2.1](#).
- Live loads (where permanent access ways may be included in the design) in accordance with AS 1657.
- Wind loads.
- Test loads in accordance with [Appendix A](#).
- Seismic loads in accordance with AS 1170.4.

- (g) Special loads as may apply to the specific ACS and due to —
- (i) loads due to thermally produced expansion or contraction;
  - (ii) snow (refer to AS/NZS 1170.3);
  - (iii) ponding of rain or hail;
  - (iv) differential settlement of foundations;
  - (v) fabrication;
  - (vi) transport;
  - (vii) rescue and evacuation; and
  - (viii) handling and erection.

### 2.2.3.3 Combination of loads

The following combinations shall be used in the determination of strength limit state:

$$\gamma_G G_k + \gamma_Q Q_{k,1} + \sum_{i > 1} \psi_i \gamma_Q Q_{k,i} \leq R / \phi$$

where

- $\gamma_G$  = partial safety factor for permanent effects
- $G_k$  = load due to permanent effects [see Item 2.2.3.2(a)]
- $\gamma_Q$  = partial safety factor for variable effects
- $Q_k$  = load due to variable effects [see Items 2.2.3.2(b) to (g)]
- $\psi$  = combination factor for variable effects
- $R$  = resistance of the structure
- $\phi$  = partial safety factor for materials

The following partial safety factors for effects shall be used:

- $\gamma_G$  = 1.0 for favourable effects
- $\gamma_G$  = 1.35 for unfavourable effects
- $\gamma_Q$  = 0 for favourable effects
- $\gamma_Q$  = 1.5 for unfavourable effects

The following combination factor for variable effects of the climber shall be used (simplified method of calculation):

- $\psi$  = 0.8

### 2.2.4 Determination of stability

The stability of an ACS shall be calculated by assessing the combinations of loads producing destabilizing effects, a combination factor of 1.2 for the permanent (self-weight) loads or 1.5 for wind and imposed action loads (climbing load and protection loads on the structure).

## 2.3 Surface integrity of the ACS surface

Surfaces of an ACS where a user may impact with the ACS, e.g. the impact strength of the climbing surface, shall be tested in accordance with [Appendix C](#) prior to installation. When the sample has been tested there shall be no penetration (i.e. an open split) of the sample and no permanent deformation of or a failure of the fastening system of panels.

## 2.4 Equipment

### 2.4.1 General

All equipment, including harnesses, ropes, karabiners, and bolt hangers, shall conform to the requirements of the applicable Australian or European Standard.

Users should follow the equipment instructions for use.

### 2.4.2 Identification

An identification system shall be used to allow all items of equipment to be identified and tracked. The identification system shall allow items to be traceable to an equipment log or specification.

### 2.4.3 Ropes, cables or webbing

Ropes to be used with devices or other fittings shall conform to the rope specification for the devices or fittings with which they are to be used.

Ropes for belay systems for climbing shall be kernmantel construction dynamic rope conforming to EN 892.

Ropes for abseiling should be of a low stretch static kernmantel construction. The construction shall conform to EN 1891 or AS 4142.3.

Ropes, cables or webbing for auto-belay systems shall conform to the specification provided by the device with which it is to be used.

### 2.4.4 Harnesses

Harnesses that conform to or exceed the design, construction and performance requirements of EN 358, EN 361, EN 813, EN 12277, AS/NZS 1891.4 or equivalent shall be used. The harness shall meet or exceed all requirements of one of these documents.

Harnesses used shall match the requirements of the user and the nature of the activity.

Harnesses should be used, maintained and repaired according to manufacturer's instructions for use.

Each harness should be uniquely identifiable and the date it was put into service recorded in the equipment log.

### 2.4.5 Harness attachment methods

#### 2.4.5.1 Top-rope

For top-roped and auto-belayed climbs the method of attaching the belay rope to the harness shall only be by using two locking forged eye captive eye karabiners (see [Figure 2.1](#)). The two karabiners shall be attached to the harness in accordance with the manufacturer's instructions (see [Figure 2.2](#)).