General Specification for the Design and Engineering of Artificial Climbing Structures

First Edition
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Climbing Wall Association, Inc.
(A Non-Profit Corporation)
8200 South Quebec Street, Box 413
Centennial, CO 80112
U.S.A.

https://www.cwapro.org

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About the Climbing Wall Association, Inc. (CWA)

The CWA is a 501(c)(06), non-profit, industry trade association incorporated in May of 2003 for manufacturers of climbing wall equipment, builders of climbing walls, operators of climbing walls, and others involved in the climbing industry. The CWA is the *only* trade association addressing the needs and interests of the climbing wall industry and climbing wall operators. The mission of the Climbing Wall Association is to support the growth, health, independence and professionalism of the climbing wall industry.

CWA Engineering Standards Committee

The Climbing Wall Association is the standard setting organization for the manufactured climbing wall industry. The CWA develops standards in two key areas: standards for the design and engineering of manufactured climbing structures and operational standards for climbing facilities (*Industry Practices*). The CWA sponsors the Engineering Standards Committee which is responsible for the development, maintenance, and revision of this specification. The CWA reserves the exclusive right to issue, or not to issue, official interpretations of any of the information contained herein. Requests for interpretations must be made in writing to the CWA.

CWA engineering standards are intended to assist architects, designers, engineers, and builders in determining adequate parameters for the design and engineering of manufactured climbing structures. CWA engineering standards relate to actual conditions of use and this specification addresses: terminology, design requirements, general requirements, live loads, marking, and conformity of artificial climbing structures in North America. The specification covers design and engineering requirements regarding the strength and stability of the structure, loads specific to climbing, as well as how and where these loads should be applied to the structure.

The engineering standards do not purport to address the safety concerns associated with the operation or use of a manufactured climbing structure. It is the responsibility of the user of this standard to consult our operational standards, establish appropriate safety and health practices, and to determine the applicability of any regulatory requirements prior to use.

CWA standards are developed and maintained in the best interests, mutually, of consumers who use climbing specialty products, manufacturers of these products, and other properly interested parties such as commercial climbing gyms and other climbing wall operators. Standards are intended to promote industry self-regulation, and to provide useful information to government, consumers, manufacturers, and owner/operators of climbing walls. The use or observance of any CWA standard is strictly voluntary.

Disclaimer: This specification is intended for use by experienced professionals. Misuse or improper interpretation of this specification may result in serious injury or death. CWA disclaims all duty, responsibility or liability to engineers, architects, designers, builders, installers, climbing wall owners, operators, employees, clients, participants or any other parties for any injury, death, or other loss resulting from any cause claimed to be related to a party's access to or use of this document.

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1.0 SCOPE

1.1 This specification addresses requirements for the design and engineering of Artificial Climbing Structures (hereafter referred to as ACSs) in regard to the strength and stability of the structure. It establishes the design loads that are specific to climbing, as well as how and where they should be applied.

1.2 This specification is applicable under conditions of Normal Use of an ACS as it relates to the techniques and protection methods used to safeguard climbers while using the ACS. In particular, this specification is based on the use of the ACS with generally accepted climbing equipment and practices. The use of equipment or practices not generally accepted by the climbing industry can lead to the generation of forces that are above those specified herein. This specification may be updated as new standards, practices, and equipment are adopted by the climbing industry. It is the user's responsibility to determine the applicability of this specification, and any other new or existing standards or practices, or lack thereof, that may affect the design and/or engineering of the ACS.

1.3 ACSs, or components thereof, designed using this specification that employ ropes shall use climbing ropes that meet UIAA 101 "Dynamic Ropes" or EN 892 "Dynamic Mountaineering Ropes – Safety Requirements and Test Methods."

1.4 This specification applies to ACSs that are fixed-in-place and stationary while in use, including temporary installations. This specification does not apply to moving surface treadmill type climbing structures. This specification does not specifically apply to portable climbing structures, or inflatable climbing structures. Mobile or kinetic climbing structures present issues beyond the scope of this specification.

1.5 This specification does not apply to *vie ferrate*, a.k.a. *klettersteige*.

1.6 This specification does not apply to challenge courses using wire rope anchors. Please see The Association for Challenge Course Technology (ACCT) standards.

1.7 This specification does not address the loads generated by auto belay devices or auto belay systems. Auto-locking or auto-assist type belay devices are not considered auto belay devices.

1.8 This standard does not purport to address the safety concerns associated with the use or operation of an ACS. It is the responsibility of the owner/operator of the ACS to establish appropriate safety, health, and operational practices for the use of the ACS prior to use.

2.0 REFERENCED DOCUMENTS

2.1 ASTM Standards:

F1773 Terminology Relating to Climbing and Mountaineering Practices.

2.2 CEN Standards:

EN 892 Dynamic Mountaineering Ropes, Safety and Test Methods.

EN 12275: 1998 Mountaineering equipment. Connectors. Safety requirements and test methods.

EN 12572 Artificial Climbing Structures- Protection Points, Stability Requirements and Test Methods.

2.3 UIAA Standards:

UIAA 101 “Dynamic Ropes”

UIAA 121 “Connectors”

3.0 TERMINOLOGY

3.1 Definitions

Terms defined in ASTM F1773 Terminology Relating to Climbing and Mountaineering Practices shall be applicable to this specification unless the term is defined in 3.2 below.

3.2 Description of Terms Specific to This Standard

3.2.1 ***Artificial Climbing Structure*** (ACS), n- a structure designed and built for the sport of climbing, including ascending, descending, and traversing over simulated rock surfaces or other climbing surfaces. ACSs may be designed and used for lead climbing, top rope climbing, and/or bouldering. ACSs may be temporary or permanent.

3.2.2 ***Belay System***, n- a system of equipment, and corresponding techniques that controls a climbing rope to provide fall protection to a moving climber or to anchor a stationary climber or belayer. Belay Systems may employ a variety of equipment and techniques and may be human-operated systems.

3.2.3 ***Protection Anchors***, n- any anchor used to secure the climber, belayer, climbing team, and/or the climbing rope to the ACS to protect the moving climber during ascent or lowering. Protection Anchors may be composed of a single point, multiple points, or a system such as a Belay Bar. The various types of Protection Anchors are distinguished based on function as follows:

3.2.3.1 ***Top Rope Belay Anchor***, n - an anchor used to secure the rope above the climber while climbing. Top Rope Belay Anchors may also be used with ropes while descending or lowering. Top Rope Belay Anchors are comprised of two or more Lead Anchors that are collectively attached to the climbing rope.

3.2.3.2 ***Belay Bar***, n- a Protection Anchor system which is fixed along the top or the bottom of the ACS and designed to secure a climbing rope or multiple climbing ropes to the ACS for belaying. Belay Bars are frequently continuous or semi-continuous pipes or bars with structural supports or attachments, but other systems may be used. A single Belay Bar typically has multiple attachments to the ACS or other support structure.

3.2.3.3 ***Belay Bar Section***, n- a part of a Belay Bar that is defined as the part between two adjacent structural supports or attachments.

3.2.3.4 ***Belay Stance***, n- a Belay Stance is a Protection Anchor for multi-pitch climbing that is designed to enable a lead climber to stop and belay a fellow

climber up to the stance before continuing the climb from the stance. A Belay Stance is used as a Protection Anchor for a lead climber and a Top Rope Belay Anchor for a following climber in an alternating fashion. A Belay Stance may have one or more people suspended on the Belay Stance at any given time and may sustain a lead fall.

3.2.3.5 ***Floor Belay Anchor***: A Protection Anchor at the base of an ACS that is designed as an anchor for Belay Systems. Floor Belay Anchors are to withstand loads generated by a climber, belayer, or a belay device. Floor Belay Anchors may be designed for top rope belay applications or lead climbing belay applications.

3.2.3.6 ***Floor Belay Anchor System***, n- a Protection Anchor system fixed to the ground at the base of the ACS and designed to secure multiple belayers or self-Belay Systems.

3.2.3.7 ***Lead Anchor***, n- A Protection Anchor that provides a single point of attachment for a climbing rope. Typically the Lead Anchor consists of an eye, loop, or ring fastened to the climbing wall structure, and the rope attachment to the Lead Anchor is accomplished via carabiners, chain, and/or slings provided by the operator of the climbing wall, but other configurations are permissable. The Lead Anchor may be used for lead climbing, retreating before reaching the top of a climb, or as a component of muti-anchor Protection Anchors such as Top Rope Belay Anchors and Belay Stances.

3.2.4 ***Climbing Route***, n- used for the purposes of determining the capacity of the climbing wall; a Climbing Route is a part of the surface of an ACS delineated by two vertical planes that are: (1) normal (perpendicular) to the surface of the ACS, and (2) the planes are 1.5 meters apart at 1.5 meters from the floor. The number of routes defined shall be greater if the manufacturer intends to provide a closer spacing, however, the number of routes shall not be considered as less than that derived by using (2) above.

3.2.4.1 ***Capacity of Utilization***, n- the maximum number of Climbing Routes on the ACS that can be used simultaneously.

3.2.5 ***Normal Use***, n- use of the ACS by un-roped climbers bouldering, or roped climbing teams consisting of a single moving climber and a stationary belayer.

3.2.6 ***Live Load***, n- The loads acting on the ACS that change over time or during the course of Normal Use. Live Loads include all of the forces that are variable during the course of Normal Use, including but not limited to: the forces imparted by stationary, moving, or falling climbers on the structure.

3.2.7 ***Dead Load***, n- The static load of the ACS that does not change over time or during the course of Normal Use. Dead Loads include the forces exerted on the parent structure or the foundation or ground at the point of attachment.

3.2.8 ***Environmental Load***, n- The loads acting on the ACS due to external forces or environmental conditions, such as wind, water, snow, and seismic activity.

3.2.9 Competent Person, n- A person possessing the skills, knowledge, experience and judgment to perform assigned tasks or activities satisfactorily as determined by the employer or other authority.

3.2.10 Qualified Person, n- An individual with a recognized degree, professional certificate, training, experience, extensive knowledge in the subject field or who is capable of design, analysis, evaluation and specification in the subject work, project, or product to the extent required by this standard.

4.0 DESIGN REQUIREMENTS

4.1 Dead and Live Loads

4.1.1 The ACS, its support structure and all portions thereof, shall be designed to sustain (within the limitations of accepted engineering practice) all Dead Loads and Live Loads identified in this specification and all relevant environmental loads covered by local building codes or known to be acting on the ACS.

4.1.2 Loads imposed by the ACS on the parent structure, if any, must also be justified by accepted engineering practice to not jeopardize the parent structure's structural integrity or viability.

4.2 Calculation of ACS Components

4.2.1 The designer is responsible for providing a complete load path for all relevant loads from the point of origin through the load resisting elements to the foundation. The designer shall justify through accepted engineering practice, the resistance capacity of the components and the various elements which make up the complete load path.

4.2.2 The designer shall justify the various elements making up the ACS according to accepted engineering practices for each material. The ACS framing elements are to be designed based upon the appropriate governing building and material code specifications, as stipulated by the local jurisdiction. When no governing building code is stipulated by the local jurisdiction, the Live Loads specified herein are to be combined with other loads per section 1605 of the "International Building Code," 2006 Edition.

4.2.3 The designer shall design the load path for strength using the Live Loads shown in Table 1 for the application being considered.

Table 1	Live Loads kN	Live Loads lbf
Lead Anchor	10 kN	2,248 lbf
Top Rope Belay Anchor	10 kN	2,248 lbf
Belay Stance	14 kN	3147 lbf
Belay Bar	(n-1) 3 + 10 kN	(n-1) 674 + 2,248 lbf
Floor Belay Anchor	5 kN	1,124 lbf
Climbing Team Load (Roped)	3 kN	674 lbf
Climber Load (Un-roped)	1.2kN	270 lbf

4.3 Protection Anchor Design

4.3.1 Requirements for Protection Anchors

4.3.1.1 All Lead Anchors must not protrude from the ACS by more than 45mm (1.77 in) and must have the minimum radius and beveled edges as shown in Figure A, diagram 1.

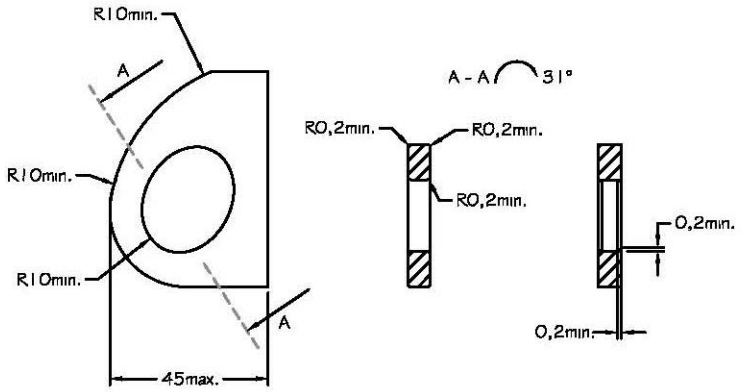

Figure A, Diagram 1, Design of Individual Protection Anchors.

4.3.1.2 Bars, pipes or devices over or through which the rope passes in a Belay Bar, belay anchor or Belay Stance, shall have an internal curvature with a radius “R” of a minimum of 4.5 mm (0.18 in)(see Figure A, diagrams 2 to 4) unless it conforms to EN 12275.

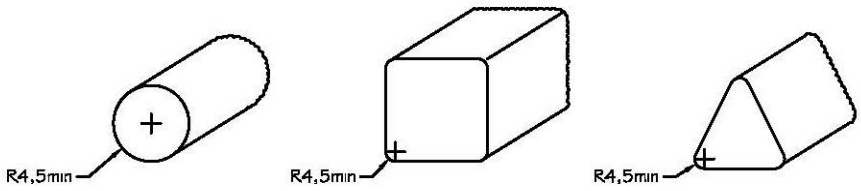

Figure A, Diagrams 2-4, Rounding of Parts.

4.3.2 Lead Anchors

4.3.2.1 Lead Anchors must provide a means of attaching a carabiner or other connector to the Lead Anchor.

4.3.2.2 Layout and placement of Lead Anchors (see Figure B).

4.3.2.3 When there are Lead Anchors, the first Lead Anchor shall be no higher than 4 meters above the finished floor (i.e. top of permanent landing surface). Spacing of second Lead Anchor shall be no more than one meter. The spacing of each subsequent anchor shall be placed at a consistent separation of between 1 to 1.3 meters (3.28 to 4.27 ft).

Alternatively apply the formula X = (H+2.0)/5 to find the maximum allowable distance "X" between each successive Lead Anchor and "H" the distance (in meters) between the Lead Anchor and the finished floor or other obstruction measured vertically beneath the Lead Anchor. The distance X shall not exceed 2 meters. For the purpose of spacing, the Top Rope Belay Anchor or Belay Stance shall be considered the last Lead Anchor and shall not exceed the calculated spacing. For Lead Anchor spacing, the maximum distance is measured from center to center of the point of attachment of the Lead Anchor to the ACS.

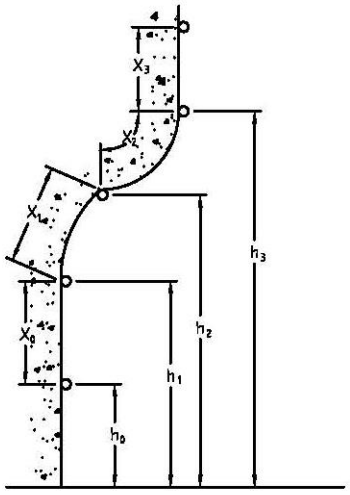

Figure B, Layout of Lead Anchors.

4.3.3 Top Rope Belay Anchors

4.3.3.1 Top Rope Belay Anchors must be comprised of a minimum of two separate and independent Lead Anchors that each meet the requirements of this specification and can both be attached to the climbing rope by means of carabiners and quickdraws or other appropriate means, unless the Top Rope Belay Anchor meets the requirements of 4.3.3.2 below. The belay anchor shall be set up so that under Normal Use the loads applied to it can be shared between the two Lead Anchors with an internal angle of separation of sixty degrees or less (see Figure C, Diagram 1). For the purposes of structural

analysis only one Top Rope Belay Anchor load shall be applied to the anchor assembly.

4.3.3.2 If a single element is relied upon to transfer the load anywhere between the climbing rope attachment point and where the load is transferred to the support structure, that element shall be designed to resist twice the load required for a normal Lead Anchor.

4.3.4 Belay Stances

4.3.4.1 Belay Stances must be comprised of a minimum of three separate Lead Anchors that each meets the requirements of this specification. The Belay Stance shall be set up so that under Normal Use the loads applied to the stance can be shared by all three Lead Anchors with an internal angle of separation of sixty degrees or less (Figure C, Diagram 2).

Diagram 1 Diagram 2

Figure C, Top rope Belay Anchor (Diag. 1) & Belay Stances (Diag. 2).

4.3.4.2 If there is to be lead climbing beyond the Belay Stance, then the subsequent Lead Anchor shall be no further than one meter away from the Belay Stance.

4.3.5 Belay Bars

4.3.5.1 When the ACS employs Belay Bars apply the formula shown in 4.3.5.2 to determine “N,” the Capacity of Utilization for each Belay Bar Section.

4.3.5.2 N=L, where “N” is the Capacity of Utilization (number of climbers, expressed as an integer) and “L” is the length of the Belay Bar Section in meters.

4.3.5.3 Belay Bars must be designed to withstand all belay anchor loads as defined in section 5 and shown in Table 1 at all points of rope contact.

4.3.5.4 Belay Bars shall be designed to contain the climbing rope on the intended bearing surface of the Belay Bar, and to not allow the rope to become detached from the Belay Bar during belaying, fall arrest, or lowering.

4.3.6 Floor Belay Anchors

4.3.6.1 Floor Belay Anchors shall meet the loading requirements listed in Table 1.

4.3.6.2 Floor Belay Anchors shall not be placed where they could conceivably be used as Lead Anchors or Top Rope Belay Anchors (e.g. on a mezzanine). Lead Anchor or Top Rope Belay Anchor loads shall apply for Floor Belay Anchors installed on mezzanines.

4.3.6.3 Floor Belay Anchors with a Top Rope Belay Anchor must lie within 15 degrees relative to the vertical line originating from the Top Rope Belay Anchor (see Figure D, Diagram 1).

4.3.6.4 If used at all, Floor Belay Anchors for lead climbing applications shall be placed as needed in or at the base of the wall (see Figure D, Diagram 2).

Diagram 1 Diagram 2

Figure D, Floor Belay Anchors.

4.3.6.5 If a Floor Belay Anchor is placed in the floor, it shall be flush mounted, or designed, located, or protected, in such a way as to attempt to reduce any hazards.

4.3.6.7 Floor Belay Anchors must be comprised of a minimum of two separate and independent Protection Anchors, unless the Protection Anchor is designed to resist twice the load required for a Floor Belay Anchor.

4.4 ACS Surface Structure Design

4.4.1 A complete load path shall be provided, and all framing and surface elements of the ACS shall be designed to resist all applicable, Live, Dead, and Environmental Loads. All applicable surface design loads shall be considered to act upon any location on the surface of the ACS.

4.4.2 The design of the surface structure shall include consideration of fatigue and puncture resistance of the surface.

4.5 Stability of ACS and Attendant Support Structure

4.5.1 Calculate the stability of the ACS according to 4.6 and/or 4.7.

4.5.2 The design of the ACS shall include a consideration of its resistance to overturning, with an applied safety factor as stipulated in the governing design code. In no case however, shall the applied safety factor for overturning be less than 1.5.

4.5.3 When designing an ACS, Environmental Loads shall be considered (e.g. wind load, snow load, seismic load, etc.) as stipulated in the local code of adoption. In the absence of local governing code, these loads shall be as specified in the "International Building Code," 2006 Edition.

4.5.4 Determine the maximum number of Climbing Routes on the ACS that may be used simultaneously. Specify the maximum number of routes as the Capacity of Utilization.

4.5.5 In no case shall the application of a Live Load be considered to act in a direction to offset, balance, or ballast an opposing Live Load.

4.5.6 Determine the Dead Load of the climbing structure.

4.6 Stability Calculation Procedure – ACS With Protection Anchors

4.6.1 Determine the Protection Anchor at which an applied load would produce the maximum instability of the ACS.

4.6.2 Apply the appropriate Live Load (as per 5.3.1) for the Protection Anchor that produces the maximum instability of the ACS.

4.6.3 Apply the Climbing Team Live Load to additional Protection Anchors to the extent that they contribute to the overturning calculated in 4.6.2 so as to produce the maximum instability of the ACS.

4.6.4 Apply the distributed Dead Load to the structure as appropriate and considered in conjunction with the Live Loads in 4.6.2, 4.6.3 and the environmental loads 4.5.3 to determine the stability of the structure.

4.6.5 Repeat the overturning calculation stability procedure for any other points that would produce a maximum instability of the structure in another direction until the structure has been shown to be stable in all usable scenarios.

4.7 Stability Calculation Procedure – ACS Without Protection Anchors

4.7.1 Determine the point at which an applied load would produce the maximum instability of the ACS.

4.7.2 Add the Climber Live Load times the Capacity of Utilization, for the section of the ACS under consideration to the same point that produces the maximum instability for that section of the ACS.

4.7.3 Alternatively, apply a 718 Newton per square meter (15 pound per square foot) uniform load so as to produce maximum instability.

4.7.4 Repeat the procedure for any other points that would produce a maximum instability of the structure in another direction until the structure has been proven to be stable in all usable scenarios.

5.0 LIVE LOADS

5.1 Live Loads: this section addresses only Live Loads generated by climbers and climbing activity on the ACS. The values for Live Loads are shown in Table 1.

5.2 Loads on Anchors: during use of the ACS climber loads, climbing team loads, and falling loads are generated on the ACS and on the Protection Anchors.

5.3 Falling Loads on Anchors: during use of the ACS loads are generated on the Protection Anchors by falling climbers being arrested by the Belay System (anchors include: Lead Anchors, Top Rope Belay Anchors, Belay Stances, Belay Bars, and Floor Belay Anchors). These loads act on Protection Anchors and the climbing wall support structure or other structure that supports the Protection Anchors. The loads are of short duration; total duration of fall arrest is typically less than 1 second, and the peak loading duration is typically less than 0.5 seconds. These falling loads shall be treated as Live Loads.

5.3.1 Application of Live Loads on Anchors: Apply the Live Loads defined in Table 1 to the climbing wall in the locations relevant to the design issue being explored at 9 degrees radially with respect to a vertical reference axis (see Figure E, Diagrams 1-3).

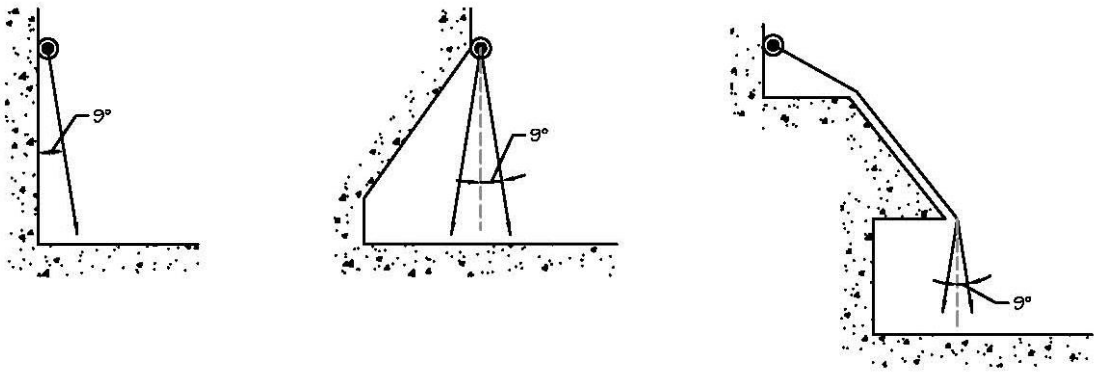

Figure E, Diagrams 1-3, Live Loads on Anchors.

5.4 Falling Loads on Floor Belay Anchors: During use of the ACS loads are generated on the Floor Belay Anchors by falling climbers being arrested by the Belay System and by climbing teams on the wall. These loads act on Floor Belay Anchors and the climbing wall support structure or other structure that supports the Floor Belay Anchors. The loads are of very short duration (approximately 0.5 second of near maximum level) and should be treated as dynamic Live Loads.

5.4.1 Application of Live Loads on Floor Belay Anchors: Apply the Live Loads defined in Table 1 to the climbing wall in the locations relevant to the design issue being

explored on a vertical axis and at a maximum of 15 degrees radially with respect to a vertical reference axis.

5.5 Climber Loads on the ACS Surface: during use the loads on the climbing surface will result from people climbing on the ACS. The climber load acts on the modular hold attachments and/or directly to the surface when there are adequate surface features.

5.5.1 Application of Climber Live Loads on the ACS Surface: apply the Live Loads defined in Table 1 to the climbing wall in the locations relevant to the design issue being explored.

6.0 GENERAL REQUIREMENTS

6.1 Equipment

6.1.1 Equipment, for the purposes of this specification, is limited to the equipment installed by the original climbing wall manufacturer.

6.1.2 All equipment originally designed and manufactured for climbing shall conform to the appropriate ASTM, CEN, UIAA or other climbing industry standards and commonly accepted climbing practices.

6.1.3 In no case shall any equipment be used that the manufacturer notes “do not use for overhead lifting,” “not recommended for overhead lifting,” “not for use with Live Loads,” “not for use with human loads,” or any similarly restrictive statement.

6.1.4 The methods used to determine the ability of equipment to support climbing loads shall be determined using the rating methods appropriate to the equipment’s original use as recommended by the original equipment manufacturer for the intended application.

6.1.5 Rated Strength for all equipment not originally designed for climbing applications shall be based on the breaking strength times a safety factor that is consistent with the safety factor used by the industry of origin or the relevant safety factor used by the climbing industry whichever is more conservative.

7.0 MARKING

7.1 All ACSs shall be durably marked in a clearly visible location with the name, trade name, or logo of the manufacturer.

7.2 All ACSs shall be marked in an accessible location (on, inside, or nearby) with the following information:

7.2.1 The name or trade name of the manufacturer including address and telephone number;

7.2.2 The name or trade name of the importer or supplier including address and telephone number, if different from the manufacturer;

7.2.3 The name or trade name of the installation company including address and phone number, if different from the manufacturer;

7.2.4 The installation date, including month and year;

7.2.5 The maximum number of Climbing Routes on the ACS that can be used simultaneously;

7.2.6 The types of climbing the ACS was designed for, or any restrictions for use. For example, if the ACS was designed only for top rope climbing it shall be marked “Top Rope Climbing Only.” If the ACS was designed for bouldering only it shall be marked “Bouldering Only, No Roped Climbing Allowed.”

8.0 CONFORMITY OF AN ACS

8.1 The ACS and its components shall be designed and built by a Competent Person, such as an experienced designer or builder in accordance with this specification.

8.2 The design of the ACS and its components shall be engineered or reviewed by a Qualified Person, for example a registered architect or a registered professional engineer in accordance with this specification.

8.3 The design plans, engineering, and an owner's manual shall be supplied to the client. The information provided to the client shall include all of the information in Section 7, Marking, the specification to which the structure was designed and built, and any manufacturer instructions for required routine inspection and maintenance of the Artificial Climbing Structure to be performed by the owner/operator.

8.4 For all reconfigurations or modifications of ACS systems, plans, engineering, and review according to this specification and the manufacturer's instructions are required.

CLIMBING WALL ASSOCIATION, INC. (CWA)
CONTACT INFORMATION & RESOURCES

The Climbing Wall Association (CWA) has many resources available for climbing wall designers and manufacturers, climbing equipment manufacturers, retailers, sales representatives, and climbing facilities.

The CWA has an informative consumer information program titled ClimbSmart!® that is designed to promote responsible climbing. The ClimbSmart!® Program is CWA's principle national public awareness campaign addressing risk in climbing sports, climbers' safety, and personal responsibility. Contact CWA or visit https://www.cwapro.org/climbsmart for more information.

Address:

Climbing Wall Association, Inc.
8200 South Quebec Street, Box 413
Centennial, CO 80112
Phone: 720-838-8284

Web Site:

https://www.cwapro.org

Email:

hello@cwapro.org