Preliminary Structural Load Assessment

Tilting Bouldering Wall
Actuators, Floor Anchorage and Rear Wall Anchorage

Executive Summary

This document presents a preliminary structural load assessment for a family of tilting indoor bouldering walls.

The purpose is to determine governing structural loads for:

• actuator sizing
• floor anchorage
• rear wall anchorage

Two load models were evaluated:

• European standard EN 12572-2
• North American design practice (CWA guidance)

The comparison shows that the European standard produces higher structural loads, primarily because it specifies a standardized climbing hold load of **0.4 kN/m² (≈ 8.36 lb/ft²)** together with a climber load of **0.8 kN (≈ 180 lbf)**.

The European standard is therefore adopted as the governing design basis.

The calculations cover wall models from **8×12 ft to 12×16 ft**.

The **12×16 wall** produces the largest loads and governs the structural design.

Maximum preliminary loads are summarized below.

Structural component	Maximum load
Actuator	13.6 kN (≈ 3057 lbf) per actuator
Floor anchorage	39.4 kN (≈ 8859 lbf) total tension
Floor anchor	3.3 kN (≈ 742 lbf) per anchor
Rear wall reaction	29.4 kN (≈ 6610 lbf)
Rear wall anchor	2.45 kN (≈ 551 lbf) per anchor

Bonded anchors are preliminarily screened using a safety factor of **5** against characteristic tensile resistance.

Table of Contents

1. Project Description
2. Design Standards

3. European Standard – EN 12572-2
4. North American Practice – CWA
5. Comparison of Load Models
6. Governing Design Standard
7. Wall Models
8. Structural Loads
9. Total Wall Mass
10. Actuator Loads
11. Dynamic Operating Loads
12. Floor Anchorage Loads
13. Floor Anchorage Layout
14. Floor Anchor Loads
15. Rear Wall Anchorage
16. Rear Wall Fixing Heights
17. Rear Wall Reaction Forces
18. Rear Wall Bracket Loads
19. Rear Wall Anchor Loads
20. Governing Structural Case
21. Anchor System
22. Anchor Embedment Depth
23. Anchor Spacing and Edge Distance
24. Anchor Screening Safety Factor
25. Uniform Embedment Acceptance – Floor Anchors
26. Mixed Embedment Acceptance – Floor Anchors
27. Rear Wall Anchor Screening
28. Installation Rules – Reduced Drill Depth
29. Anchor Design Verification
30. Design Load Summary

List of Symbols and Units

Symbol	Description
kN	kilonewton
lbf	pound-force
kg	kilogram
lb	pound
m	meter
ft	foot
m^2	square meter
ft^2	square foot
kNm	kilonewton meter
M	overturning moment
F	reaction force
h	fixing height
NRk	characteristic anchor resistance
Napplied	applied anchor load

---

1 Project Description

This document provides a preliminary structural load assessment for a tilting indoor bouldering wall system.

The calculations estimate loads acting on:

• actuators
• floor anchorage
• rear wall anchorage

---

2 Design Standards

Two design philosophies were evaluated:

1. EN 12572-2 – Artificial climbing structures
2. North American design practice (CWA guidance)

---

3 European Standard – EN 12572-2

Characteristic loads for bouldering walls:

Climber load
0.8 kN (≈ 180 lbf)

Climbing hold load
0.4 kN/m^2 (≈ 8.36 lb/ft^2)

Equivalent masses:

Load type	Standard value	Mass equivalent
Climber	0.8 kN (≈ 180 lbf)	≈ 80 kg (≈ 176 lb)
Climbing holds	0.4 kN/m² (≈ 8.36 lb/ft²)	≈ 40 kg/m² (≈ 8.2 lb/ft²)

Loads must be applied in the most unfavorable position.

---

4 North American Practice – CWA

Typical assumptions:

- **270 lb per climber**
- **two climbers simultaneously**

Total climber load

540 lb (≈ 2.4 kN)

Actual hold weight is typically used instead of a standardized load.

---

5 Comparison of Load Models

Reference wall

3.66 m × 3.66 m
(12 ft × 12 ft)

Area

13.40 m² (≈ 144 ft²)

European model

Component	Load
Plywood	174 kg (≈ 383 lb)
Steel frame	250 kg (≈ 551 lb)
Climbing holds	536 kg (≈ 1182 lb)
Climber	80 kg (≈ 176 lb)
Total	1040 kg (≈ 2293 lb)

North American model

Component	Load
Plywood	174 kg (≈ 383 lb)
Steel frame	250 kg (≈ 551 lb)
Holds	102 kg (≈ 225 lb)
Climbers	245 kg (≈ 540 lb)
Total	771 kg (≈ 1700 lb)

---

6 Governing Design Standard

The European model produces higher loads.

Therefore **EN 12572-2** governs the design basis.

---

7 Wall Models

Wall model	Dimensions
8×12	2.44 m × 3.66 m (8 ft × 12 ft)
10×12	3.05 m × 3.66 m (10 ft × 12 ft)
12×12	3.66 m × 3.66 m (12 ft × 12 ft)
12×14	3.66 m × 4.27 m (12 ft × 14 ft)
12×16	3.66 m × 4.88 m (12 ft × 16 ft)

---

8 Structural Loads

Component	Value
Plywood panels	13 kg/m² (≈ 2.66 lb/ft²)
Steel frame	scaled with wall area
Climbing holds	0.4 kN/m² (≈ 8.36 lb/ft²)
Climber	0.8 kN (≈ 180 lbf)

---

9 Total Wall Mass

Wall size	Total mass
8×12	720 kg (≈ 1587 lb)
10×12	880 kg (≈ 1940 lb)
12×12	1040 kg (≈ 2293 lb)
12×14	1200 kg (≈ 2646 lb)
12×16	1360 kg (≈ 2998 lb)

---

10 Actuator Loads

Maximum loads occur at **70° overhang**.

Wall size	Actuator load
8×12	7.2 kN (≈ 1618 lbf)
10×12	8.8 kN (≈ 1978 lbf)
12×12	10.4 kN (≈ 2338 lbf)
12×14	12.0 kN (≈ 2698 lbf)
12×16	13.6 kN (≈ 3057 lbf)

---

11 Dynamic Operating Loads

(no climbers)

Wall size	Actuator load
8×12	4.2 kN (≈ 944 lbf)
10×12	5.3 kN (≈ 1191 lbf)
12×12	6.3 kN (≈ 1417 lbf)
12×14	7.4 kN (≈ 1664 lbf)
12×16	8.4 kN (≈ 1888 lbf)

---

12 Floor Anchorage Loads

Rear anchor centroid located:

0.82 m (≈ 2.69 ft) behind front support.

Wall model	Floor anchorage force
8×12	16.4 kN (≈ 3687 lbf)
10×12	19.7 kN (≈ 4429 lbf)
12×12	23.0 kN (≈ 5171 lbf)
12×14	30.7 kN (≈ 6902 lbf)
12×16	39.4 kN (≈ 8859 lbf)

---

13 Floor Anchorage Layout

• 2 floor brackets
• 6 anchors per bracket

Total anchors

12

---

14 Floor Anchor Loads

Wall model	Load per floor bracket	Load per floor anchor
8×12	8.2 kN (≈ 1844 lbf)	1.37 kN (≈ 308 lbf)
10×12	9.85 kN (≈ 2214 lbf)	1.64 kN (≈ 369 lbf)
12×12	11.5 kN (≈ 2585 lbf)	1.92 kN (≈ 432 lbf)
12×14	15.35 kN (≈ 3451 lbf)	2.56 kN (≈ 576 lbf)
12×16	19.7 kN (≈ 4429 lbf)	3.28 kN (≈ 737 lbf)

Maximum floor anchor load

3.3 kN (≈ 742 lbf)

---

15 Rear Wall Anchorage

Rear wall stabilizes the wall structure.

---

16 Rear Wall Fixing Heights

Kickboard height	Fixing height
25 cm (≈ 9.8 in)	1.10 m (≈ 3.61 ft)
57.5 cm (≈ 22.6 in)	1.44 m (≈ 4.72 ft)
90 cm (≈ 35.4 in)	1.76 m (≈ 5.77 ft)

---

17 Rear Wall Reaction Forces

Wall model	1.10 m	1.44 m	1.76 m
8×12	12.25 kN (≈ 2753 lbf)	9.36 kN (≈ 2104 lbf)	7.66 kN (≈ 1722 lbf)
10×12	14.70 kN (≈ 3305 lbf)	11.23 kN (≈ 2524 lbf)	9.19 kN (≈ 2066 lbf)
12×12	17.15 kN (≈ 3856 lbf)	13.10 kN (≈ 2945 lbf)	10.72 kN (≈ 2410 lbf)
12×14	22.86 kN (≈ 5140 lbf)	17.47 kN (≈ 3928 lbf)	14.29 kN (≈ 3212 lbf)
12×16	29.40 kN (≈ 6610 lbf)	22.46 kN (≈ 5048 lbf)	18.38 kN (≈ 4132 lbf)

---

18 Rear Wall Bracket Loads

Two brackets share load.

For **12×16 wall**:

Fixing height	Bracket load
1.10 m (3.61 ft)	14.70 kN (≈ 3305 lbf)
1.44 m (4.72 ft)	11.23 kN (≈ 2524 lbf)
1.76 m (5.77 ft)	9.19 kN (≈ 2066 lbf)

---

19 Rear Wall Anchor Loads

Each bracket uses **6 anchors**.

Maximum rear wall anchor load:

14.70 / 6 = **2.45 kN (≈ 551 lbf)**

---

20 Governing Structural Case

The **12×16 wall** governs:

• actuator loads
• floor anchorage
• rear wall anchorage

---

21 Anchor System

Bonded anchors:

• M12 threaded rod (≈ 1/2 in)
• 14 mm drill hole (≈ 0.55 in)
• steel grade 8.8
• adhesive equivalent to **Hilti HIT-HY 200-A**

---

22 Anchor Embedment Depth

Embedment depth	Concrete thickness
60 mm (2.36 in)	120 mm (4.72 in)
80 mm (3.15 in)	140 mm (5.51 in)
100 mm (3.94 in)	160 mm (6.30 in)
120 mm (4.72 in)	180 mm (7.09 in)

---

23 Anchor Spacing and Edge Distance

Parameter	Value
Anchor spacing	120 mm (≈ 4.72 in)
Minimum edge distance	90 mm (≈ 3.54 in)

---

24 Anchor Screening Safety Factor

Preliminary screening uses:

NRk / Napplied ≥ **5**

---

25 Uniform Embedment Acceptance – Floor Anchors

Wall model	60 mm	80 mm	100 mm	120 mm
8×12	OK	OK	OK	OK
10×12	OK	OK	OK	OK
12×12	No	OK	OK	OK
12×14	No	No	OK	OK
12×16	No	No	No	OK

26 Mixed Embedment Acceptance – Floor Anchors

(max 1 reduced depth anchor)

Wall model	1×60 + 5×80	1×60 + 5×100	1×100 + 5×120
8×12	OK	OK	OK
10×12	OK	OK	OK
12×12	OK	OK	OK
12×14	No	OK	OK
12×16	No	No	OK

27 Rear Wall Anchor Screening

Maximum rear wall anchor load

2.45 kN (≈ 551 lbf)

All embedment depths acceptable.

28 Installation Rules – Reduced Drill Depth

If reinforcement is encountered:

• only one anchor may be reduced in embedment depth
• reduced anchor should not be placed in the most critical location

29 Anchor Design Verification

Final design shall follow

EN 1992-4

30 Design Load Summary

Component	Maximum load
Actuator	13.6 kN (≈ 3057 lbf)
Floor anchorage	39.4 kN (≈ 8859 lbf)
Floor anchor	3.3 kN (≈ 742 lbf)
Rear wall reaction	29.4 kN (≈ 6610 lbf)
Rear wall anchor	2.45 kN (≈ 551 lbf)