The effect of load rate, placement angle, and ice type on ice screw failure load

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Overview

What is ice climbing, what forces occur during a fall, & why study ice screws?

Methods

Results

Conclusions & Speculation
Climber’s gravitational potential is converted to spring energy in the rope during a fall. Expect forces on the order of 3 kN to 12 kN, perhaps as high as 20 kN.
Why Bother & Who Cares

- Dearth of data and conflicting data
- Word from the wall is “don’t fall.”
- Ice screws are little changed from the 1980s

- Climbers
- Manufacturers
- Standards Folks
Bad ice  
Good ice (-18°C)

Three angles:  
–30º, 0º, 30º

Pull to failure, two strain rates: 25 mm/s and 0.25 mm/sec

Measure force and displacement  
High speed video record
High Speed Video
Fast Strain Rate, 0°
High Speed Video
Slow Strain Rate, 0º
Little Picture Results

(a) Failure Load, kN vs. Placement Angle, Degrees

- WI-S
- WI-F
- AI-S
- AI-F
- WI-S Long
Big Picture Results

![Graph showing failure load vs placement angle for different conditions including WI-S, WI-F, AI-S, AI-F, Harmston, Luebben, DAV/OAV, and WI-S Long.](image-url)
Conclusions & Suspicions

• Strain rate matters; ice climbers should reduce strain rate.
• The combined effects of angle, strain rate, and ice type are complicated.

• Ice in compression is stronger than ice in tension.
• Temperature matters.
• Better ice screws can be designed.
• Ice screw standards deserve another look.
Thanks to

- Warren & Stef, who did all the hard work
- The Aero/Astro 16.62x lab folks
- Luca for the ice climbing photo
Questions?
## Results – Stage 2

<table>
<thead>
<tr>
<th>Ice Type</th>
<th>Rate</th>
<th>Angle</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>SD/ mean</th>
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<tbody>
<tr>
<td>ABS1</td>
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<td>-30</td>
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