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

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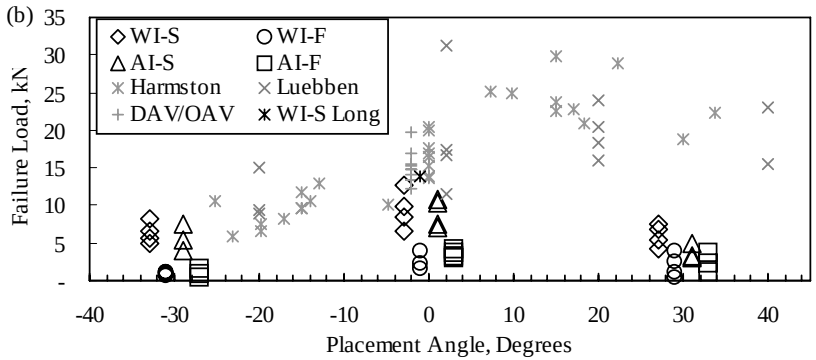
Overview

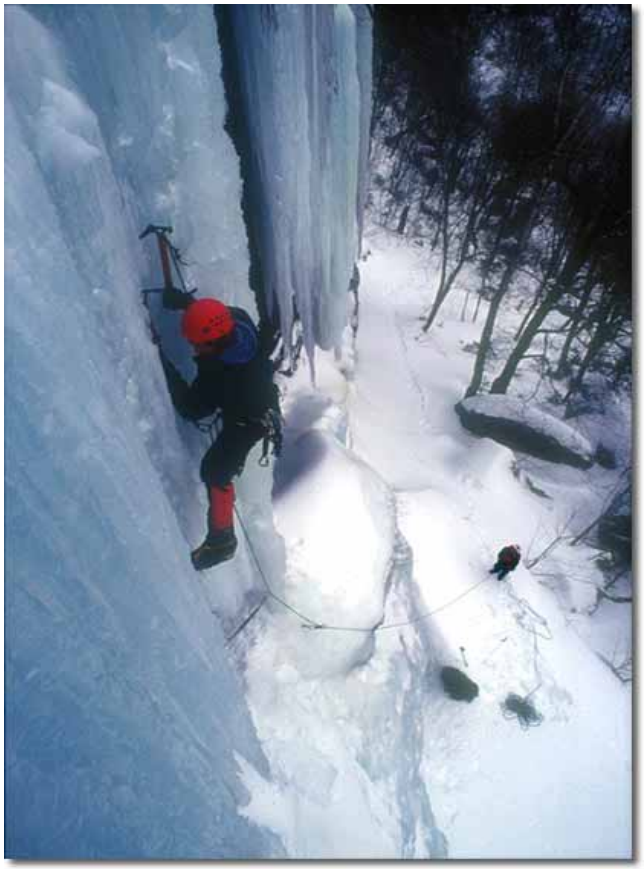
What is ice climbing, what forces occur during a fall, & why study ice screws?

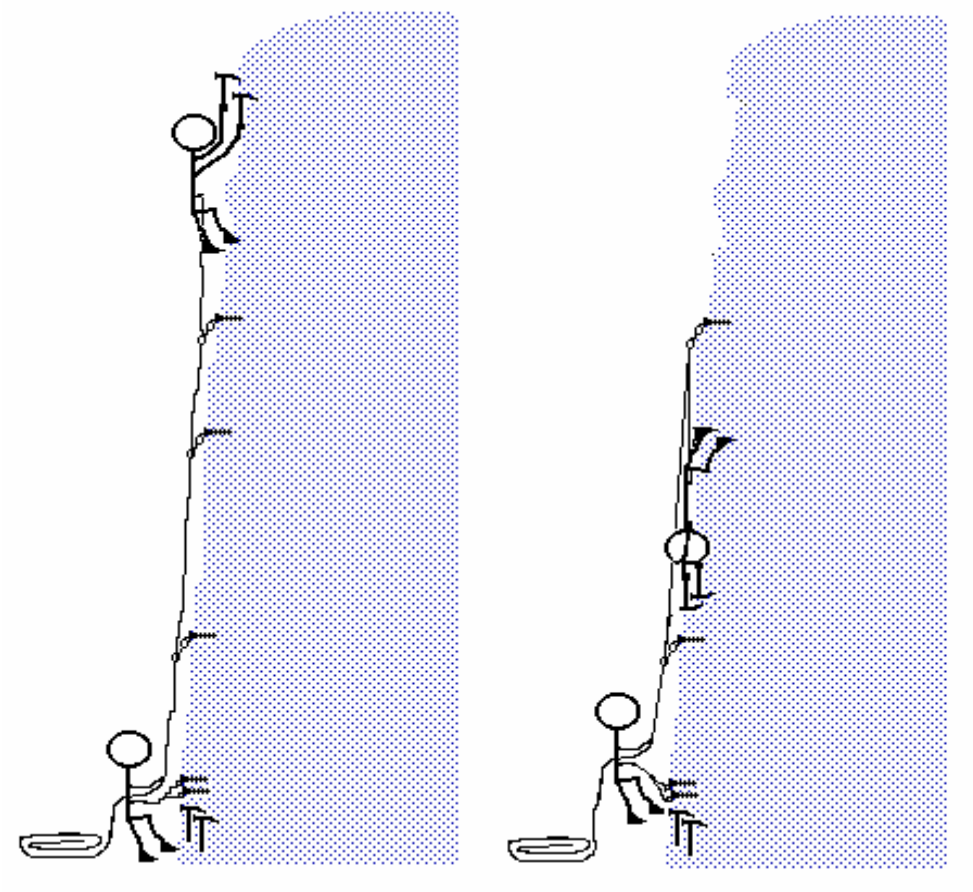
Methods

Results
Conclusions
& Speculation



Ice Climbing & Force on Ice Screw





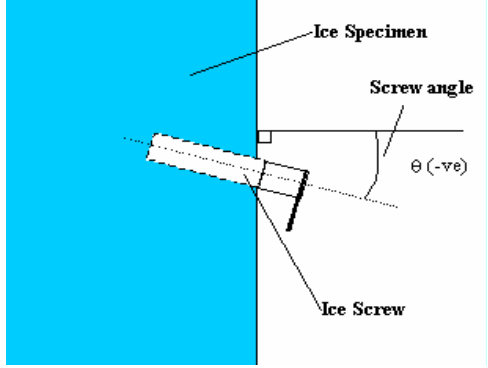
Climber's gravitational potential is converted to spring energy in the rope during a fall. Expect forces on the order of 3 kN to 12 kN, perhaps as high as 20 kN.

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

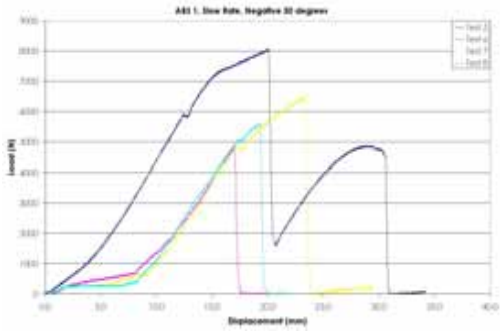
- Climbers
- Manufacturers
- Standards Folks

Bad ice
Good ice
(-18ºC)

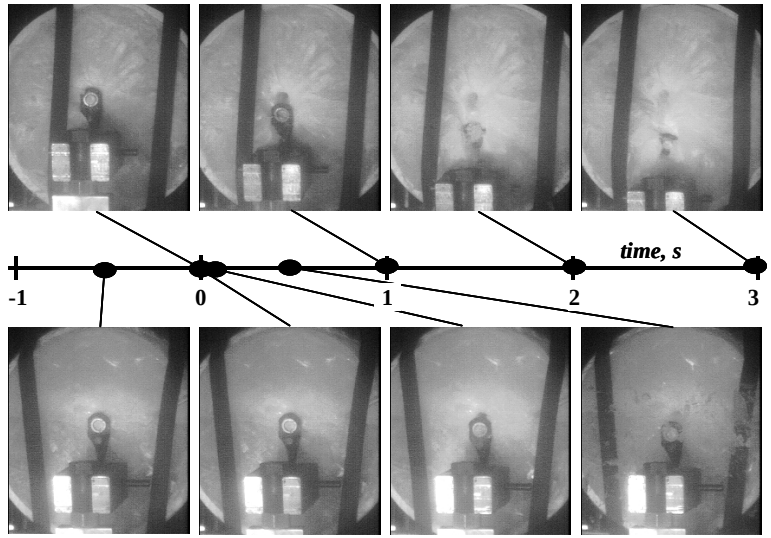


Three angles:
–30º, 0º, 30º

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

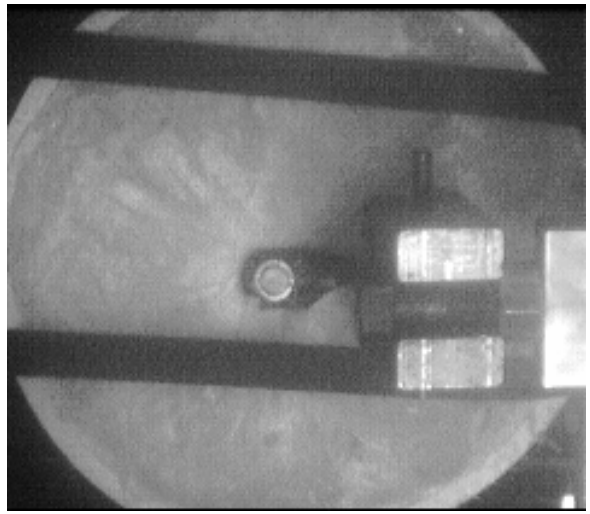


Measure force and displacement

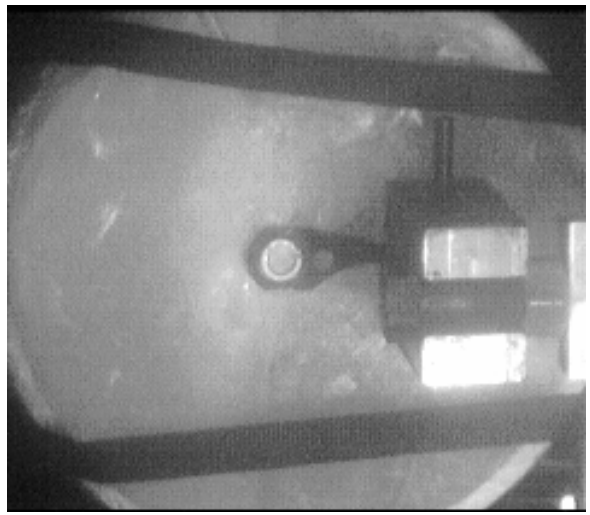


High speed video record

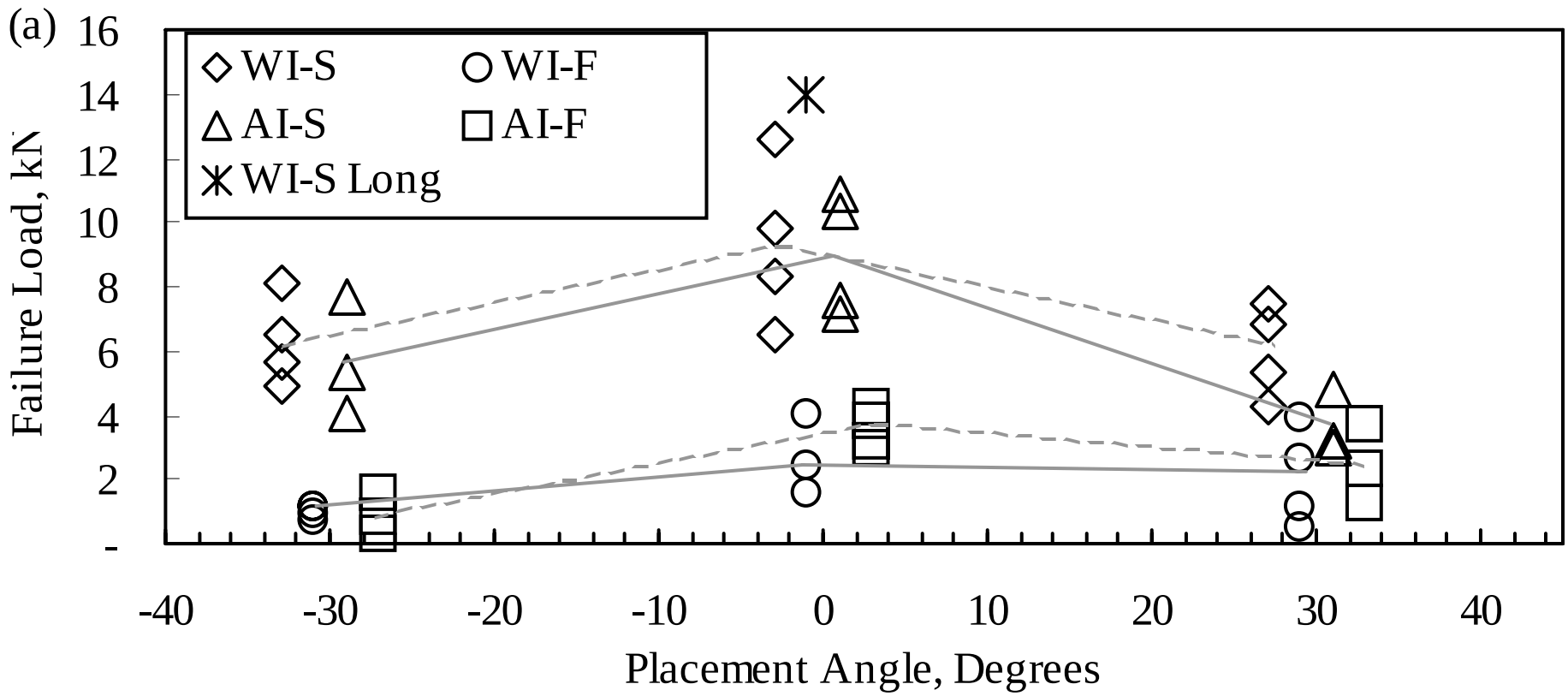
High Speed Video
Fast Strain Rate, 0º



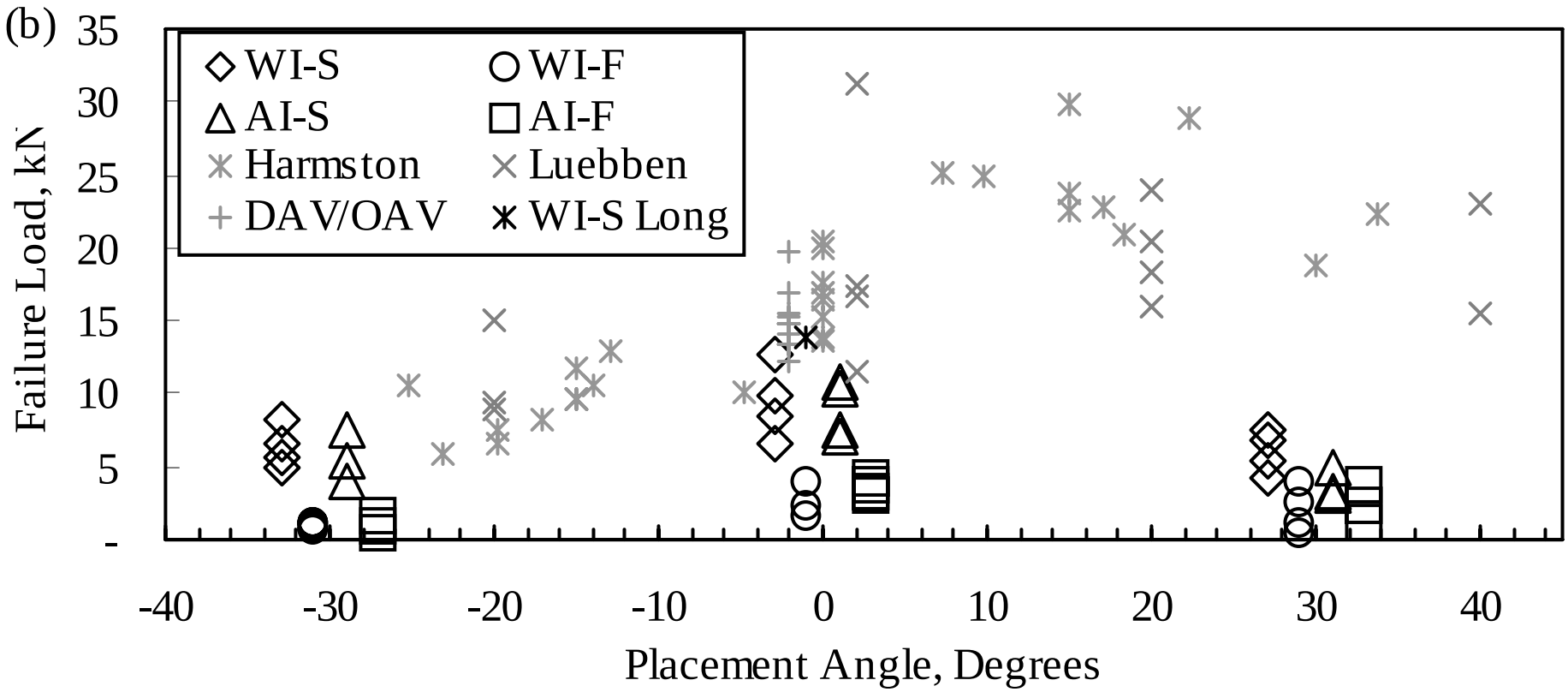
High Speed Video
Slow Strain Rate, 0º



Little Picture Results



Big Picture Results



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

Ice Type	Rate	Angle	Mean	Std. Dev.	SD/ mean
ABS1	0.01	-30	1394	309	22%
ABS1	0.01	0	1660	294	18%
ABS1	0.01	+30	1329	322	24%
ABS2	0.01	-30	1220	410	34%
ABS2	0.01	0	2375	75	3%
ABS2	0.01	+30	810	243	30%
ABS1	1.0	-30	229.75	47	21%
ABS1	1.0	0	446	142	32%
ABS1	1.0	+30	708	481	68%
ABS2	1.0	-30	211	142	68%
ABS2	1.0	0	697	25	4%
ABS2	1.0	+30	547	276	51%