WATER KNOT TESTING

Anecdotal evidence exists to suggest that water knots, commonly used to join webbing into a sling, sometimes fails by slipping. I have found through testing on a load frame that this knot gradually slips when cycled repeatedly with loads as low as body weight. When the tails have slipped all the way into the knot, it fails. This resolves the concern I had about "mysterious" failures of the knot. I believe it is completely safe to use as long as it is checked and found to have sufficient tails before loading.

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3/22/99

Summary

Anecdotal evidence exists to suggest that water knots - commonly used to join webbing into a sling - sometimes fail by slipping. I have found through testing on a load frame that this knot gradually slips when cycled repeatedly with loads as low as body weight. When the tails have slipped all the way into the knot, the knot fails. This resolves the concern I have had about "mysterious" failures of this knot. I believe it is completely safe to use as long as it is checked and found to have sufficient tails before loading.

Background

I have been told many anecdotal stories of accidents caused by the failure of water knots (also called ring bends or overhand follow-through bends) by slipping. Understanding these failures is of some concern to mountain rescuers who use this as a standard knot for tying two ends of a webbing sling together. Many climbing and rescue texts recommend leaving plenty of tail with this knot and pretensioning it carefully to avoid possible slipping, but none of them provides any detail on failures. Past pull-testing I have done on water knots (with sufficient tails) showed ***no*** slipping failures - no matter how poorly the knot was dressed or how poorly it was pretensioned. This caused me some consternation. If a knot occasionally has mysterious failures that I can't duplicate, should we be using that knot for rescue work? Suggestions by other climbers (and the temporary availability of a programmable load frame) prompted me to look at the possibility that these knots were slipping over time under repeated loading and unloading cycles, rather than by slipping when loaded for the first time.

Test Methods

I used a small MTS load frame to pull on a loop of 9/16" tubular webbing tied with a water knot. The load was cycled from 0 to 250 lbs at a fairly slow loading and unloading rate (about two seconds per cycle). Loads and extensions were measured directly by the load frame. The test was halted automatically upon failure of the knot.

Results

The test showed consistent slipping of one of the tails into the knot at an average rate of 0.0035 inches per cycle. A knot that started with tails almost three inches long had one tail gone after 806 cycles. It was interesting to note that only one of the tails slipped into the knot - the one on the "top" side of the knot.

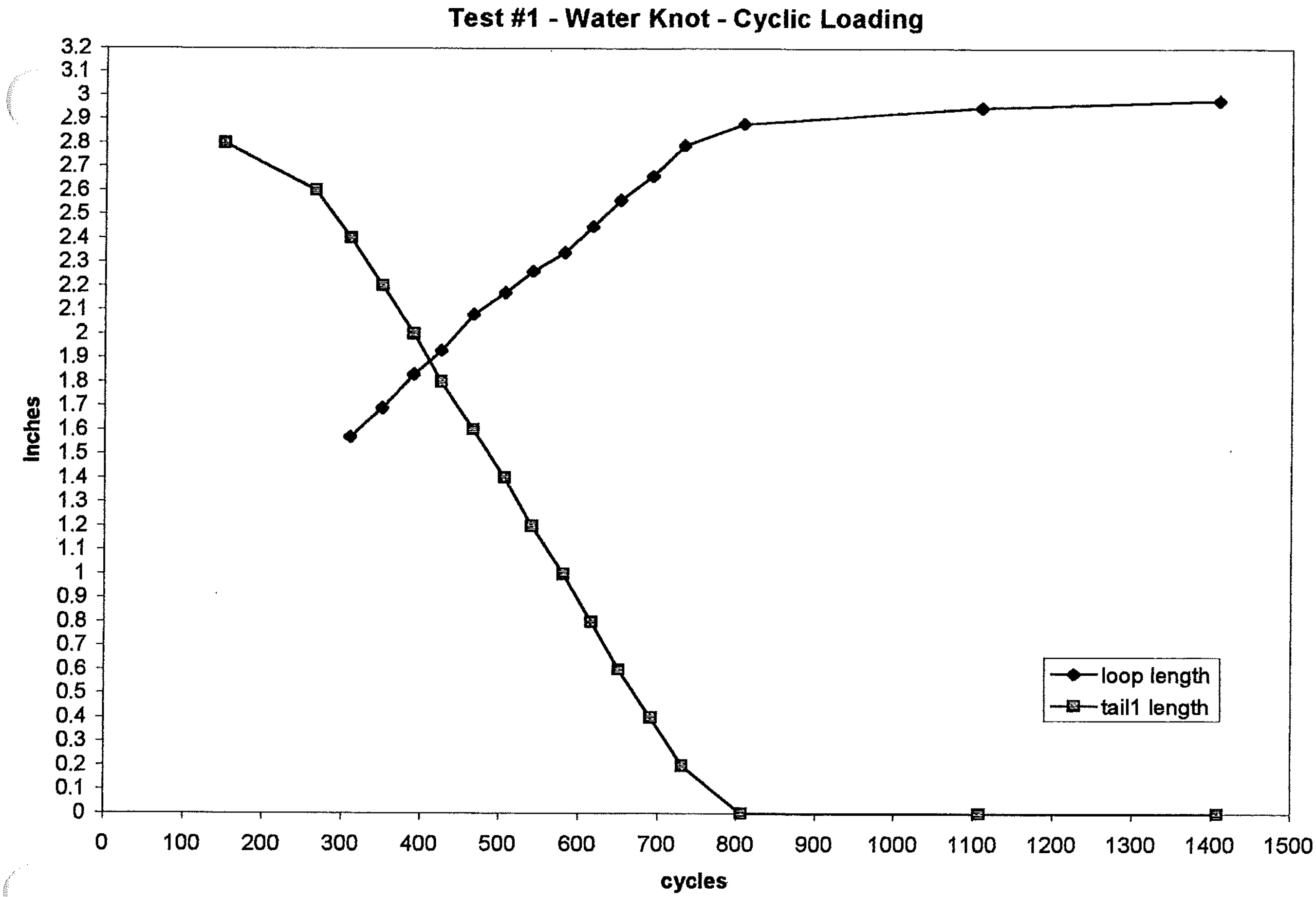
A test with overhand safeties on the water knot gradually slipped through 1.75 inches of tail, and then cinched and did not slip any further. Interestingly, the slip rate was not linear as in the first test, but decreased as the safeties gradually tightened.

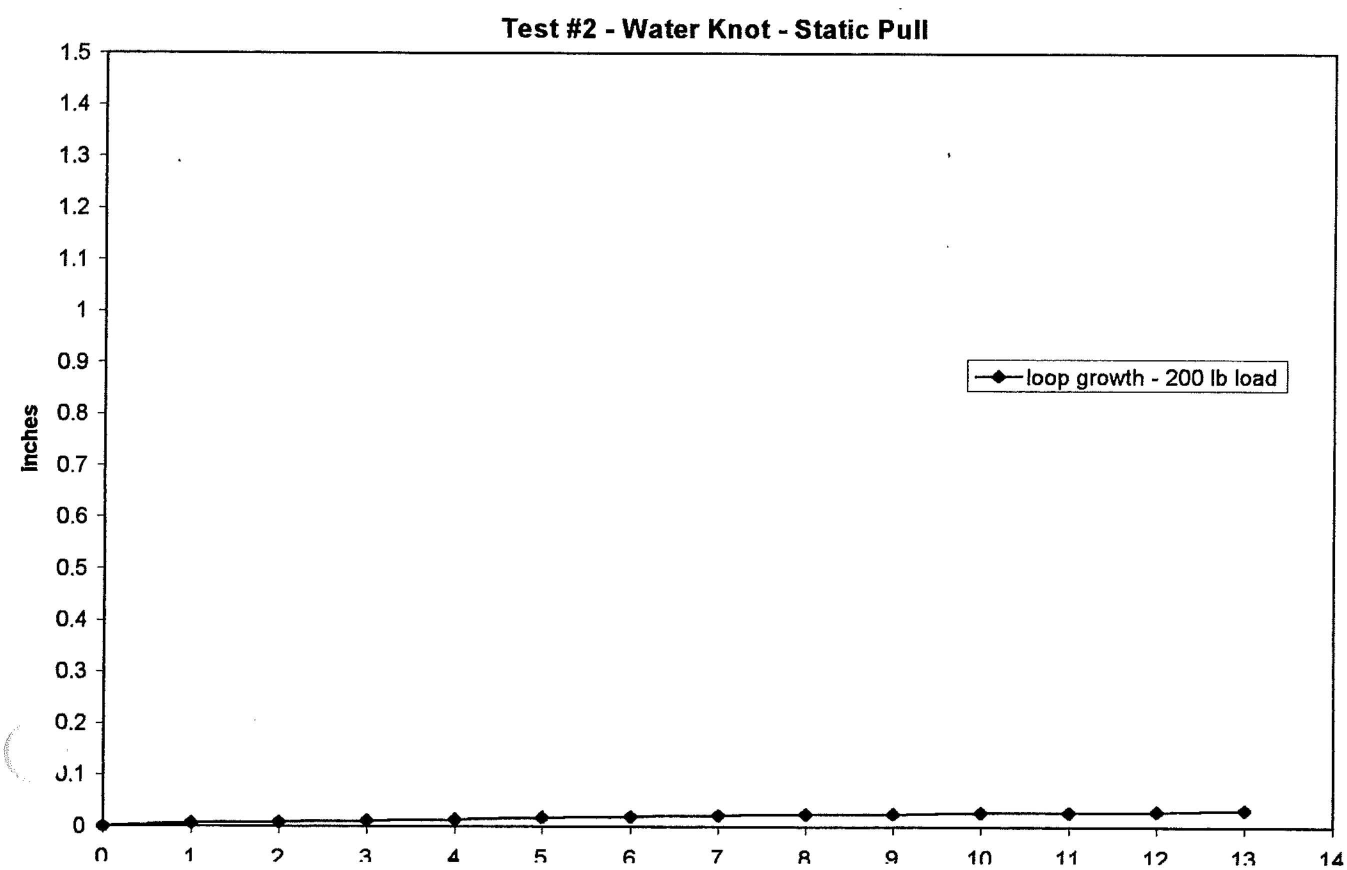
A loop tied with a water knot was loaded with a static pull of 200 lbs to check whether the knot was slipping by creeping. The test was run for thirteen minutes. After an initial period of setting the knot, no further slipping occurred. The water knot seems to be affected by loading and unloading, not by a static pull.

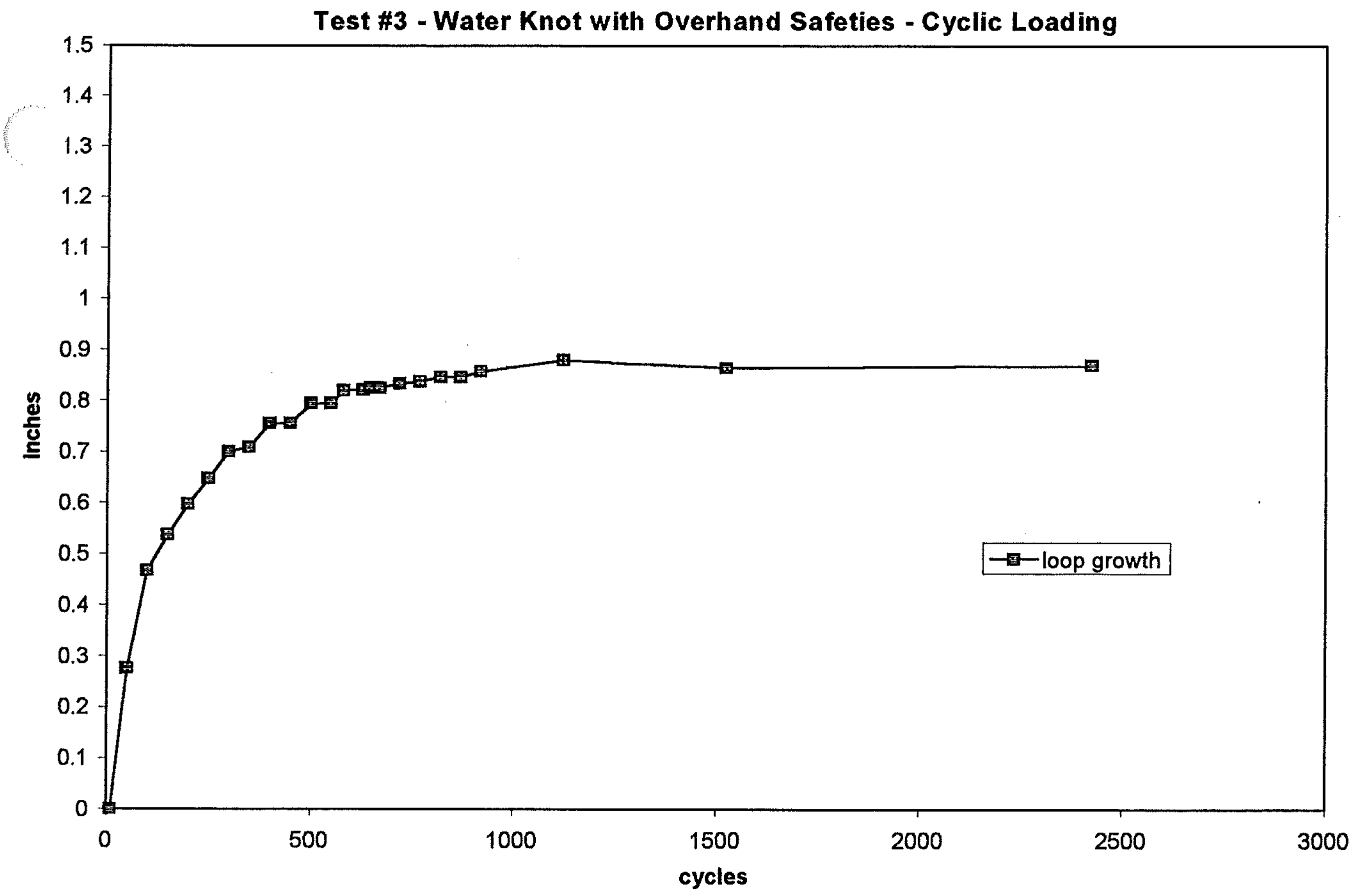
Another cycle test was done on a loop tied with a single fisherman's knot. Over the first 1000 cycles, the loop elongated by 1/4 inch as the knot set. After that, no further elongation occurred. The test was discontinued at 1630 cycles.

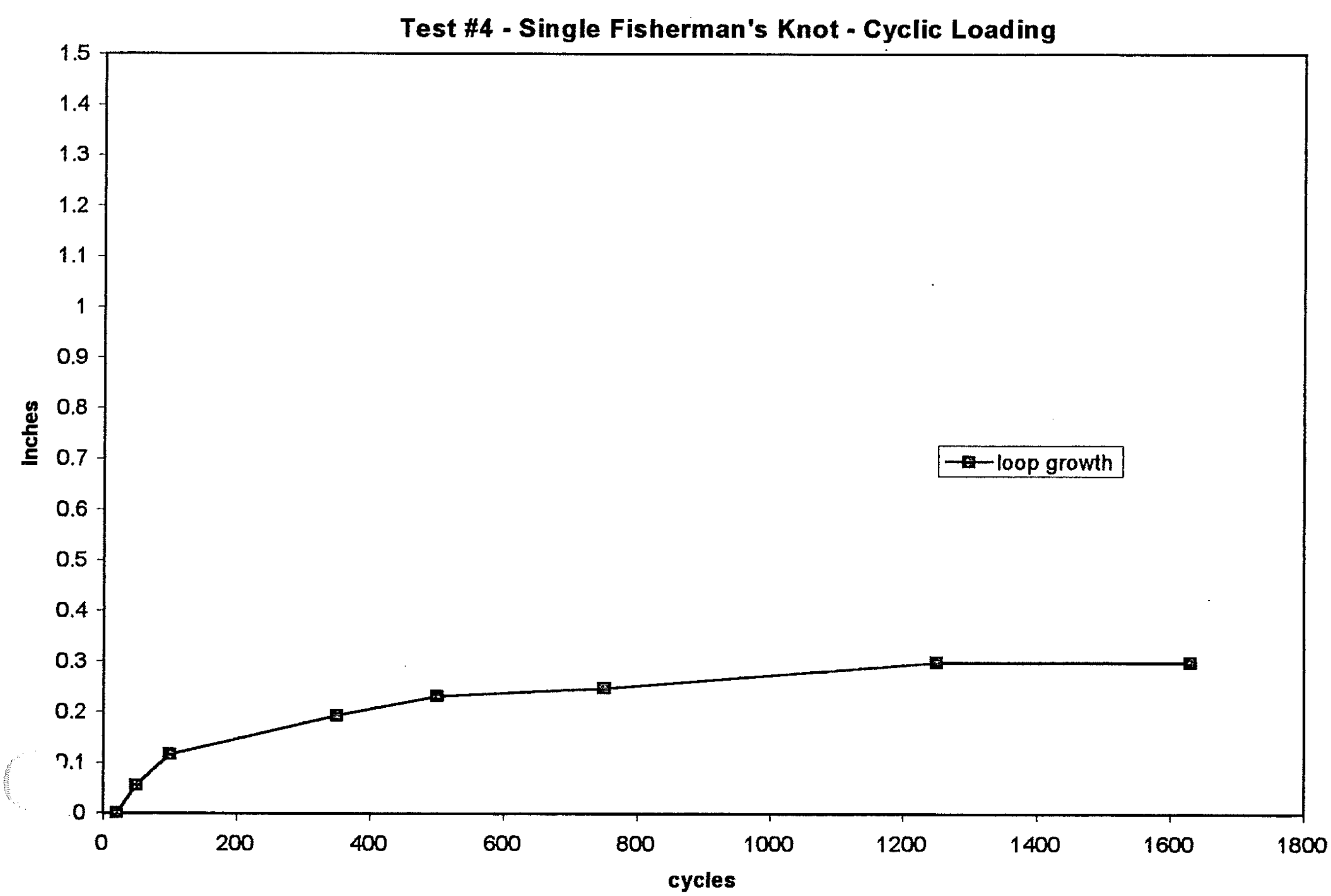
Conclusions

Water knots definitely fail by slipping under cyclic loading. Low loads, such as body weight, are sufficient to cause failure. Other knots (such as a single fisherman's) tied in the same material do not exhibit this kind of failure. Overhand safeties tied on top of a water knot may prevent the failure, but do not guarantee it. This is not all bad news for water knots. I now understand the mechanism of failure and know how to prevent it. This is a lot more comforting than using a knot about which I have suspicions. I will always check the length of the tails on every water knot - and particularly every fixed rappel anchor tied with a water knot - before trusting my life to it. We will continue to use water knots in Salt Lake County, and continue to require long tails on this knot as we always have.


Test #1 - Water Knot - Cyclic Loading
Inches
cycles
loop length
tail1 length
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500


Test #2 - Water Knot - Static Pull
Inches
loop growth - 200 lb load
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14


Test #3 - Water Knot with Overhand Safeties - Cyclic Loading
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Inches
0
500
1000
1500
2000
2500
3000
cycles
loop growth


Test #4 - Single Fisherman's Knot - Cyclic Loading
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.0
Inches
0
200
400
600
800
1000
1200
1400
1600
1800
cycles
loop growth