

Empirically Derived Breaking Strengths for Basket Hitches and Wrap Three Pull Two
Webbing Anchors
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Riggers often have strong opinions about the webbing anchors they use, and will often cite 'pull test' data to support their opinions. When asked to provide the data or a citation for the data referenced, most riggers are unable to provide a source since the data was never published. This empirical research program addresses the problem of open source uniformly conducted pull test data by publishing the results of 34 slow pull tests on basket hitches and 35 slow pull tests on wrap three pull two (W3P2) anchors.

Measurements of breaking strengths were conducted on a Baldwin universal testing machine with DP41 digital load deflection upgrade electronics with an internal load cell range of 0 to 200,000 lbs, at the College of Engineering, Montana State University. The two spools of new unused one inch tubular PMI webbing used were from lot number 45105 and loom 514. One of the two spools had a splice, and the splice point was not included in any of the anchors measured. Eight feet of webbing was used for basket hitches and nine feet was used for W3P2 anchors, and all anchors were tied by one person (A.S.) to retain consistency. Anchors were tied around a 4 inch steel pipe filled with concrete and the attachment point was a half inch diameter, four inch tall steel screw link purchased from a hardware store. Basket hitch knots were placed behind the metal pipe while the W3P2 knots were placed on the front of the pipe facing the load. Each anchor was built and quickly loaded up to ~8000 lbs (~82 lbs per second) then the rate of loading was decreased (~14 lbs per second) till breakage occurred. Raw breaking strengths were multiplied by the force multiplier determined by the internal angle of the anchor to calculate the load experienced by the anchor. Scaled data was used to calculate all statistics.

Basket hitches (N=34) broke at an average load of 9943.2 lbs with a standard deviation of 642.4 lbs, with a maximum load of 11244.2 lbs, and a minimum of 8902.2 lbs. W3P2 anchors (N=35) broke at an average load of 9167.3 lbs with a standard deviation of 1075.4 lbs, with a maximum load of 11695.5 lbs, and a minimum of 7445.3 lbs. To test the null hypothesis that the two anchors broke at the same average strength, a two-tailed Z-test was performed yielding a P-value of .000212 ($\alpha=.05$, critical value 1.959964), suggesting there is a statistically significant difference between the breaking strengths of the two anchor types.

The same statistics were calculated removing all data from measurements that had abnormalities associated with them which yielded the same general trends. Basket hitches (N=27) broke at an average load of 9928.3 lbs with a standard deviation of 627.7 lbs, with a maximum load of 11208.9 lbs, and a minimum of 8902.2 lbs. W3P2 anchors (N=33) broke at an average load of 9221.6 lbs with a standard deviation of 1064.4 lbs, with a maximum load of 11695.5 lbs, and a minimum of 7455.3 lbs. The two-tailed Z-test yielded a P-value of .001494 ($\alpha=.05$, critical value 1.959964), also suggesting there is a statistically significant difference between the breaking strengths of the two anchor types.

These data suggest basket hitches in the configuration tested are approximately 705 to 775 lbs stronger than W3P2 anchors and break with less variability (smaller standard deviation) than W3P2 anchors. Webbing anchors break at lower strengths than expected, though in all cases the anchors were stronger than a 11mm nylon rope (~6000

lbs), suggesting both anchor types are acceptable rescue anchors when tied correctly. Generally variability was observed in the breaking strength of anchors made from webbing from within a spool and between spools.

In all trials the anchors broke at the screw link and not at the knot, suggesting that the knots are not the weak point in the anchors in the configuration tested. Basket hitches tended to break at two locations simultaneously (24 or 71%), while W3P2 anchors broke in two locations less frequently (8 or 23%). In 4 trials (11%) one strand of a W3P2 anchor broke, however the anchor held until pulled further since the loaded webbing held the anchor in place even with the severed strand. In addition, the W3P2 anchors made many more noises during loading than the basket hitches.