Strength Loss Due To Aging of 1 Inch Tubular Nylon Webbing

Thomas Evans, SAR[3], http://sarrr.weebly.com/

Introduction

Nylon products slowly degrade, reducing their strength and performance with use and age. Manufacturers of life safety equipment (rope, cord, and webbing) have provided rules of thumb concerning when to retire equipment, but have not provided any published estimates of product strength loss over time. Given the versatility of webbing and its numerous uses, it would be useful to have an estimate of how much strength is lost per year due to aging alone; riggers could thus estimate the average strength of their anchors given their configuration and webbing age. While estimating anchor strength would certainly not be a precise process, having an estimate of strength loss per unit time would facilitate determining when to retire webbing due to age alone.

Presented here are webbing strength measurements for webbing with known ages. These data show both the variability in webbing strength and the approximate strength loss over time.

Materials and Methods

One inch tubular nylon webbing of various ages was pull tested at CMC Rescue by Cedric Smith utilizing the standard manufacturers webbing pull test method. Generally this includes high strength tie-offs (4 complete wraps) on both webbing ends around 4 inch diameter bollards, a pull rate of between 10 to 20 cm/min (4 to 8 in/min), and measurement of the breaking strength with a calibrated load cell.

The webbing was pulled out of the CMC Rescue training caches, meaning it was used by rescuers in normal training and then pulled out of service. As a result, the webbing experienced both aging and normal use, so the results reported here include both variables. A control series of ten pieces of new unused webbing were also broken as a baseline to compare old sample strength against.

Breaking strengths (y-axis) were plotted versus webbing age (x-axis), and a linear regression was performed to estimate the strength loss over time (e.g., slope of the regression line). The breaking strengths are reported in both kilonewtons (kN) and pounds force (lbs) so anyone can access the information easily.

Results

The raw data is reported in Table 1 (in both kN and lbs) and shows webbing breaking strength decreases with age (Figure 1A in kN, and Figure 1B in lbs).

A linear regression of all data returned an equation of Y = -0.2574X + 18.469 (in kN) with an R^2 value of 0.7311. The equation is Y = - 57.871 X +4152.1 when the regression is performed on the data expressed in pounds, which of course yields the same R^2 value. This equates to approximately a 0.26 kN (58 lbs) reduction in webbing strength per year. This is about a ~1.45% decrease in strength relative to the original breaking strength per year. It should be acknowledged that an R^2 value of 0.7311 indicates that there is quite a bit of variability in webbing breaking strength at any given age, which can in part be attributed to different use histories.

One way to reduce the "noise"/variability in the dataset is to analyze the two endpoints: 0 years (new webbing) and 20 years. Including only the webbing data with large sample sizes in a given year enables comparisons between two populations, which yields similar results to the entire data set. A line drawn through the averages of both data sets yields an equation of $Y = -0.2457 X + 18.941$ (in kN) and $Y = - 55.235 X + 4258$ (in lbs). No R^2 value is appropriate to report here because this is just a line between two points, so does not represent a regression of data. These two equations indicate that even when comparing two populations, there is an average webbing strength reduction of about 0.25 kN or 55 lbs per year.

Discussion and Conclusions

These data illustrate two points. First, there is a small strength loss in 1 inch tubular webbing of about 0.26 kN or 58 lbs per year, which is the same as about a 1.5% strength loss per year. Second, there is a wide range of breaking strengths for webbing of a given age. This means that the strength loss per year reported here can be applied to populations and not individual pieces of webbing. In other words, subtracting about 0.26 kN or 58 lbs per year will only give you an estimate for the breaking strength of the average piece of webbing in a population. About half of the webbing will break above this value and about half will break below this value. So this should be used as a guideline for when to retire webbing products, but not a hard and fast rule of how to estimate the minimum breaking strength of a piece of webbing.

Some of the variability in the webbing is due to differences in use history. Because the webbing is used equipment, some of the webbing received more use and/or more wear. This source of error means that the numbers here can only be reasonably used to estimate webbing strength over time. However, as an estimation tool, it is a useful one, even if it is not precise. For example, if you are interested in knowing about how long it would take for webbing to lose about 10% of its strength, it is simple algebra (the answer is about 7 years*).

When to retire webbing is a personal choice. Generally, if in doubt, throw it out. And obviously, if the webbing has received some sort of damage (e.g., cuts, abrasion, dissolution from acid, etc.), it should be retired. However, for webbing that has been used reasonably, has not experienced shock loads, and is well maintained, a rigger can decide how much strength loss (on average) they are willing to accept in their equipment before retiring it. No rule will be advocated here, other than imploring users to base their decisions on data. It is hoped that this short article provides just the kind of information users may need to make these kinds of decisions.

Acknowledgements

This short article was the result of John McKently handing me some unpublished testing data at the International Technical Rescue Symposium in 2013. The data sat around in my desk for a while until I thought about analyzing it. John kindly gave me permission to publish the data, and this article is the result. As such, this would not have been possible without John taking the initiative to give me the data, and giving me permission to make it public. Similarly, all the testing was performed by Cedric Smith at CMC Rescue. Testing of this nature is time intensive, laborious, and boring, so he deserves all the credit for performing the hard part of this study. Lastly, Sarah Truebe provided editorial suggestions, guidance, and corrections, though all mistakes and omissions remain the fault of the author alone.

*Example Calculation: $10\% = (1.5\%) X$

$(10\%)/(1.5\%) = X$

$X = 6.67$ Years

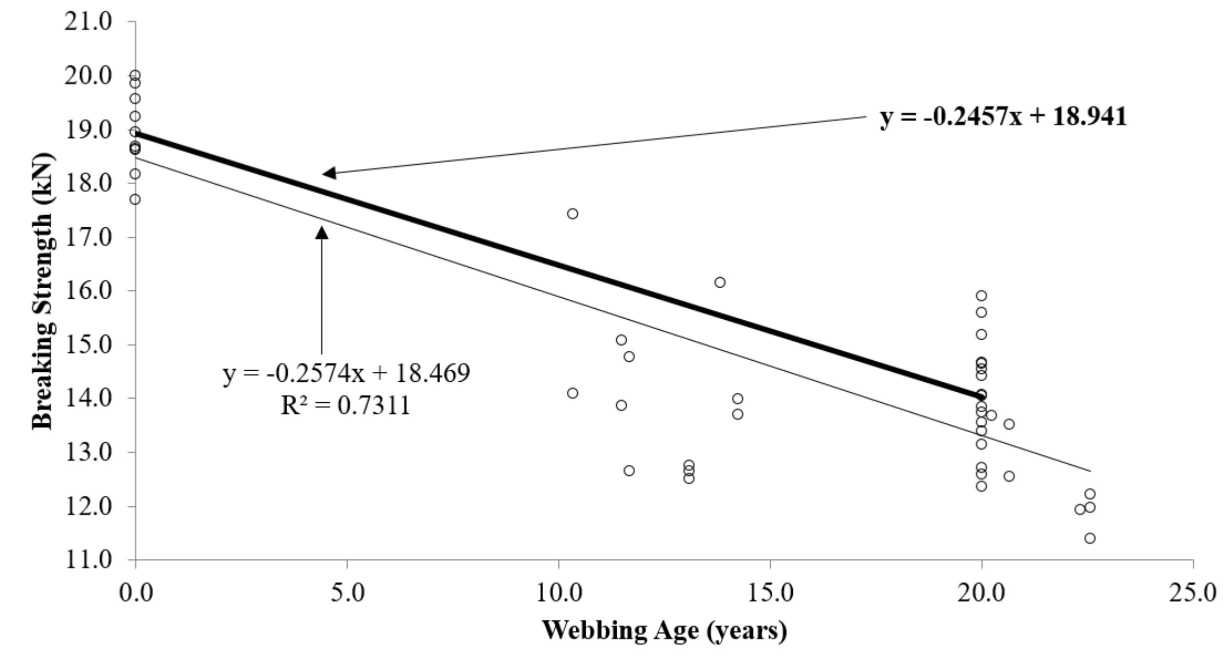

Figure 1A: One inch tubular nylon webbing breaking strength (kN) versus age (years). The lower line is a regression line including all the data, while the upper (thick) line is drawn through the averages of the populations at 0 years of age and 20 years of age. The lower equation and R2 value corresponds to the regression line, while the upper equation corresponds to the upper line.

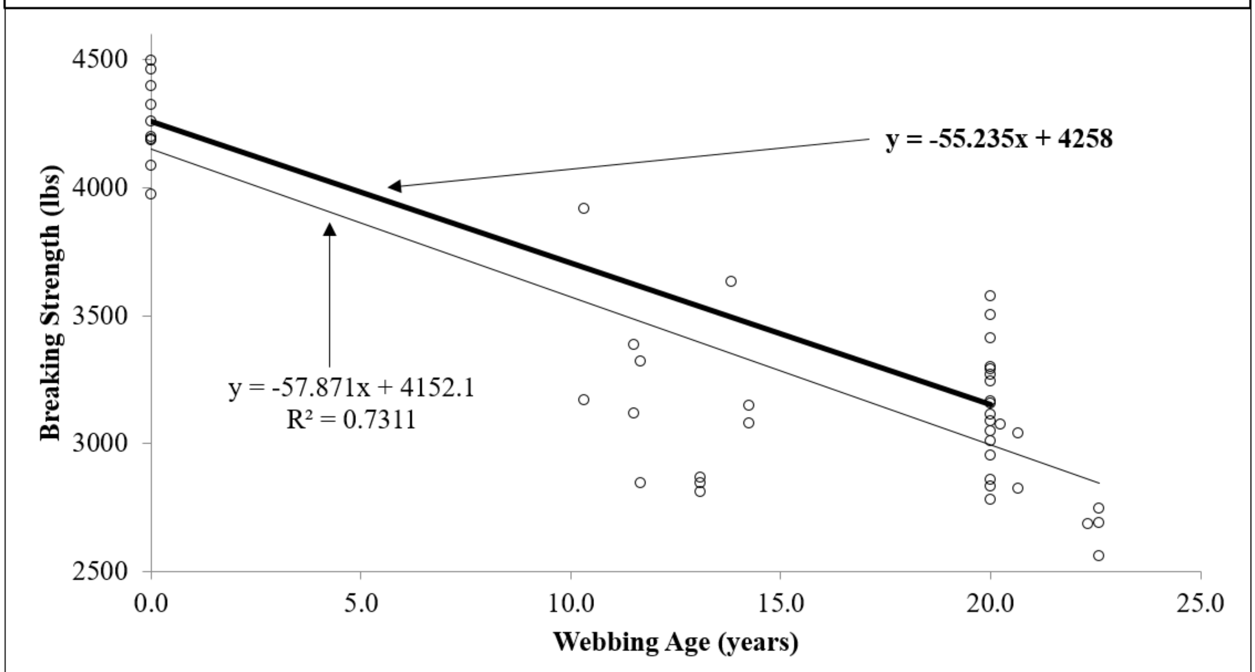

Figure 1B: One inch tubular nylon webbing breaking strength (lbs) versus age (years). The lower line is a regression line including all the data, while the upper (thick) line is drawn through the averages of the populations at 0 years of age and 20 years of age. The lower equation and R2 value corresponds to the regression line, while the upper equation corresponds to the upper line.

Table 1: Sample ages in years and breaking strengths in both kN and lbs.

Sample #	Total Age (Years)	Breaking Strength (kN)	Breaking Strength (lbs)	Sample #	Total Age (Years)	Breaking Strength (kN)	Breaking Strength (lbs)
1	0.00	18.62	4185	24	20.00	14.65	3293
2	0.00	18.95	4261	25	20.00	14.42	3242
3	0.00	19.57	4399	26	20.00	15.59	3504
4	0.00	19.24	4326	27	20.00	15.19	3414
5	0.00	18.63	4189	28	20.00	13.14	2954
6	0.00	17.69	3976	29	20.00	13.85	3113
7	0.00	18.17	4085	30	20.00	12.37	2781
8	0.00	19.86	4465	31	20.00	13.75	3090
9	0.00	20.00	4496	32	20.00	13.38	3009
10	0.00	18.67	4198	33	20.00	14.04	3157
11	10.33	17.43	3918	34	20.00	14.67	3298
12	10.33	14.10	3170	35	20.00	12.60	2832
13	11.50	13.87	3117	36	20.00	14.08	3165
14	11.50	15.07	3388	37	20.00	15.91	3576
15	11.67	12.66	2845	38	20.00	13.55	3047
16	11.67	14.77	3320	39	20.00	12.72	2860
17	13.08	12.76	2868	40	20.25	13.68	3076
18	13.08	12.65	2844	41	20.67	12.56	2823
19	13.08	12.50	2811	42	20.67	13.52	3040
20	13.83	16.15	3631	43	22.33	11.94	2684
21	14.25	14.00	3147	44	22.58	11.97	2690
22	14.25	13.69	3078	45	22.58	12.22	2747
23	20.00	14.55	3271	46	22.58	11.39	2561