Cycle Fatigue Effects on Aramid and Combined Fiber Ropes

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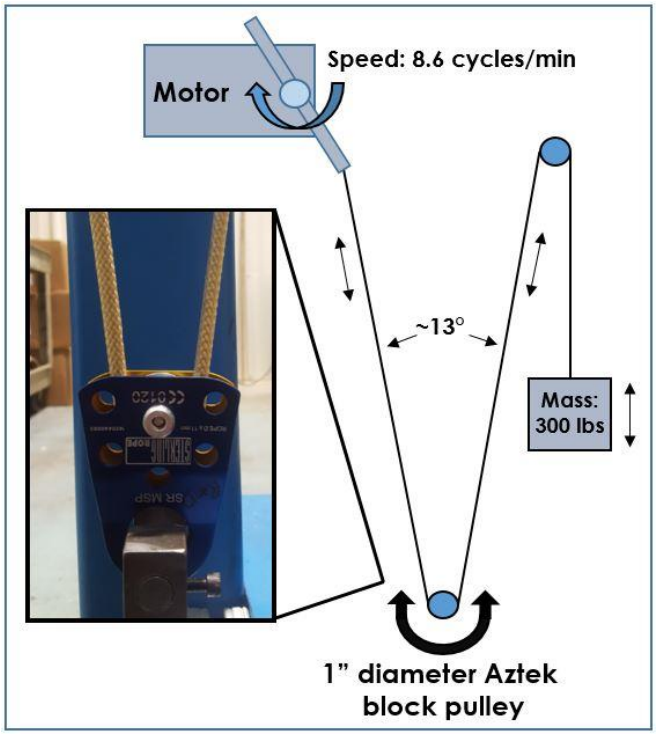
Overview – A summary of the results of cycle fatigue testing several rope constructions of approximately 8mm diameter containing aramid fibers.

Background - Aramid fibers have been in use in the life safety and rescue world for more than 20 years in various forms and applications. Originally utilized for their heat resistant properties, they have continued to gain acceptance for various other beneficial attributes, including high tensile strength, low elongation, cut and abrasion resistance. These highly desirable characteristics have long been understood to come with a significant caveat, namely that of what is commonly known as “flex fatigue” or “cycle fatigue”, the fact that these fibers lose strength with repeated loading and bending, as was most noteably demonstrated in the Moyer – Harmstrong ITRS paper in 2000.

Purpose – Many rescuers utilize a personal kit consisting of set of small pulleys, 50 feet of 8mm cordage, assorted connectors, and a few prusik loops. Christened the AZTEK by Reed Thorne of Ropes That Rescue, these kits have become somewhat ubiquitous in the rescue world, affectionately known to have 101 uses.

There has been recent interest in offering a more durable cordage solution for these kits, one with greater resistance to cutting and abrasion than the current 8mm nylon cord which is provided. A series of different tests indicated that the use of aramid fibers in the host rope would offer an measurably increased cut resistance. However, the effects of repeated cycling over the pulley was not yet quantified. Testing was warranted to determine the most appropriate cord construction for this application.

Testing Setup - To evaluate the effects of repeated cycle loading on various aramid rope, an apparatus was constructed to automatically cycle a rope over a pulley sheave, while raising a 300 pound load. Running at 8.6 cycles per minute the system would count up to a prescribed number of cycles then stop. Samples were analyzed using 250, 500 and 1000 cycles. Upon completion of each test, each sample was then pull tested for residual tensile strength. A minimum of 5 samples of each were subjected to each cycle count, to allow for a somewhat more robust statistical analysis than a single sample.



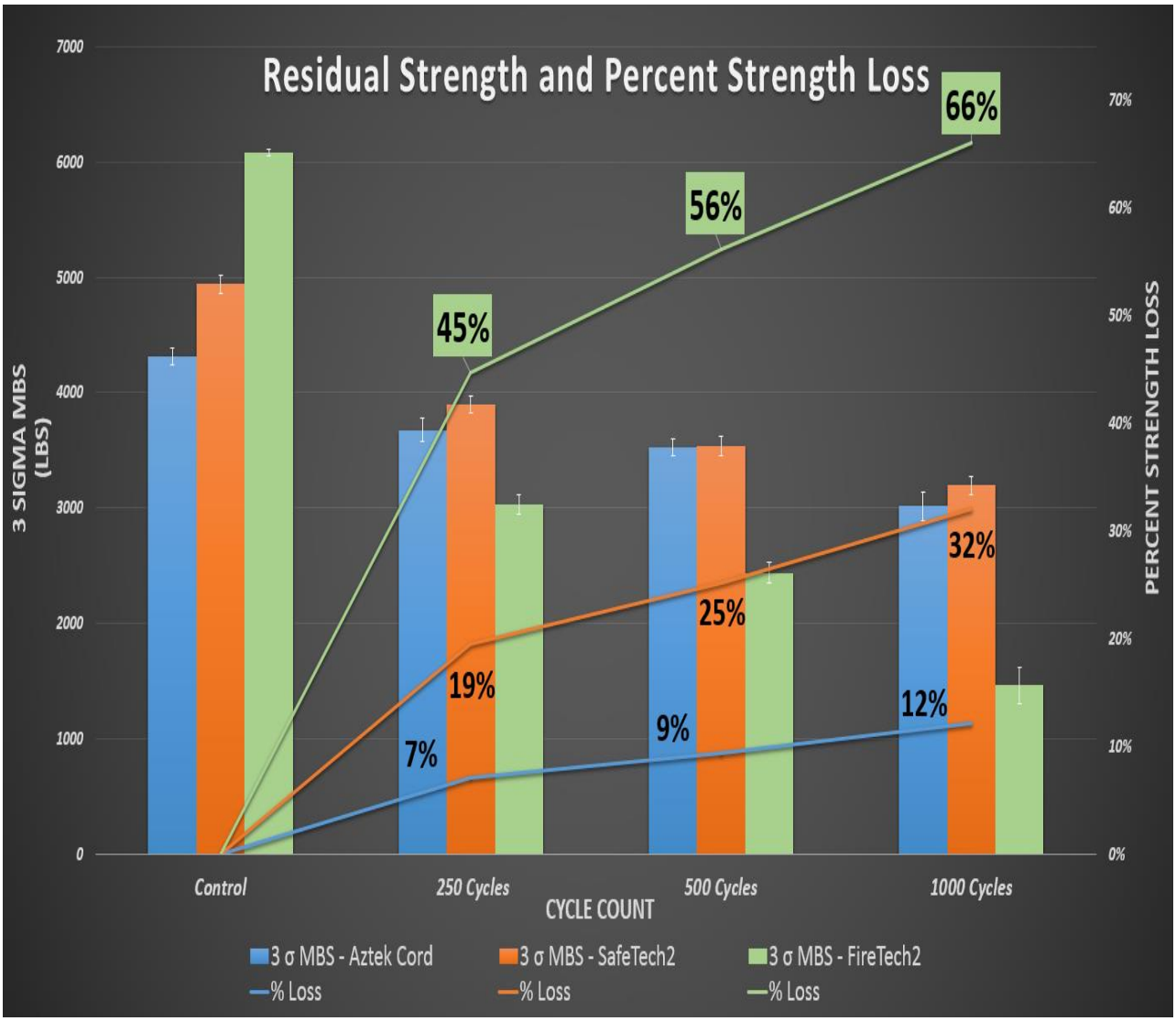
Ropes Tested – 3 ropes of various constructions and configurations were evaluated, including:

FireTech2 – 100% aramid rope, certified to NFPA for Personal Escape. 7.5mm

SafeTech – Sheath of aramid fiber, with a nylon core. Certified to NFPA for Personal Escape. 8mm

Personal Escape Rope – 100% nylon fiber. Certified to NFPA as a Personal Escape rope. 8mm – This is the rope currently offered in an AZTEK

Results Summary - Ropes with a 100% aramid construction exhibited the highest tensile strength when new, however that strength dropped off quickly as it was cycled. Ropes with a nylon construction showed a lower initial strength, but suffered much less percentage loss, even at the high end of the cycle count. Fitting neatly in between these two were rope with a combined fiber construction, in this case an aramid sheath, and nylon core. These ropes still showed a significant loss of strength, but maintained an overall higher final strength at high cycle counts. These results would not necessarily be the same for other ropes with a nylon core and aramid sheath, as the amount of load each component carries varies for various ropes.



Conclusion : As expected, aramid fibers exhibited significant strength loss with repeated cycling, however, by using aramids in the sheath and nylon in the core, the overall loss can be mitigated to a certain extent, while preserving the desired benefit.

Next Steps – These same questions exist in larger diameter ropes used in rescue and rope access scenarios. Further testing would be interesting to determine if these results could be used to forecast the results for larger ropes, to determine proper retirement criteria.