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RESEARCH REPORT

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Is that tie-in point safe to use?

by Brian Kane, PhD

Tree climbing is an inherently dangerous task. Working at height is dangerous by itself; but add the use of sharp cutting tools and rigged pieces of wood to the job, and it's not surprising that our industry has a comparatively high incident rate. To increase safety while climbing, climbers must choose a tie-in-point (TIP) that can bear the loads applied as the climber ascends and then works in the tree. Failure of the TIP isn't an everyday occurrence, but it has happened, even during an ascent. To reduce the likelihood of failure of the TIP, climbers attempt to assess its load-bearing capacity by visual inspection and performing a "bounce test," but very little research has explored the likelihood of TIP failure.

Figure 1 *shows the Straightpoint LLC load cell used to measure forces during the Ascent event at the 2017 ITCC in Washington, DC.*

In 2017, at the ITCC in Washington, DC, I measured forces at the TIP during the "Ascent" event – this is the event that replaced the secured footlock. From the measurements, I wanted to learn how large were the forces at the TIP, what was their frequency of application, and whether they differed among different ascent techniques that competitors used. Most competitors used two foot ascenders, but some footlocked and others used a single foot ascender.

To measure forces, the team running the Ascent event installed a load cell between the anchor point on the tree and the rigging hub that climbers attached their lines to. The load cell (Figure 1), made by Straightpoint LLC, measures the force 100 times each second, so it's possible to obtain a detailed record of the forces throughout each competitor's ascent—this is called a force time history. Figure 2 shows the force time history for a ten second segment of one competitor's footlock—it might remind you of an EKG. The time history shows a series of peak forces as the climber extended their body upwards after locking the rope with their feet. The peak forces occur at regular time intervals, which describes the frequency of peak forces, that is, how many peak forces occur in a specified time interval. Using two foot ascenders applied about the same force as footlocking, but at twice the frequency—twice as many peaks in the same time interval.

To assess the likelihood of failure of a TIP during an ascent, we need to know both the amount of the peak force, and how frequently it's applied. The reason for this is because as its loaded by the ascending climber, the TIP bounces up and down. The interaction of the repeated application of peak loads with the natural tendency of the TIP to respond by bouncing may cause the effect of the force to be multiplied. This means that even if the peaks are well below the load-bearing capacity of the TIP, the bouncing action can increase the likelihood of failure.

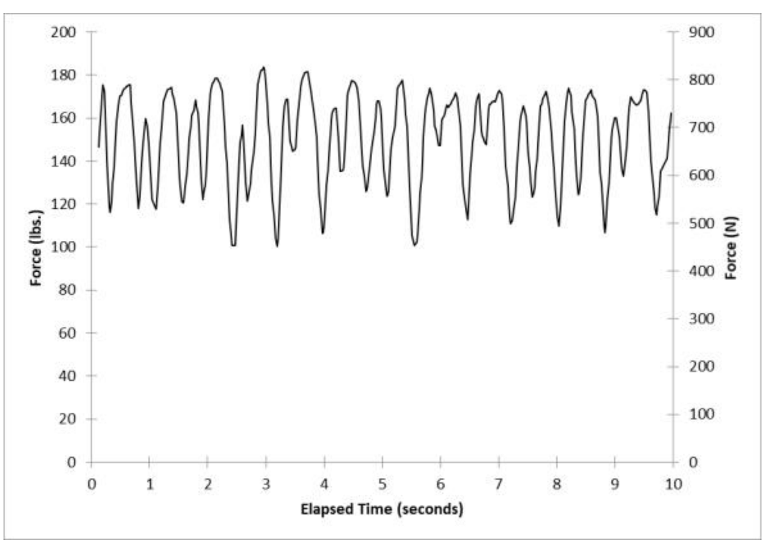

Figure 2 *The black line shows changes in the load on an anchor point during ten seconds of an ascent.*

In general, peak forces were about 1.3 – 1.4 times body weight, and, depending on how long the ascent lasted, there could be 20 – 50 peak loads in total. This type of loading on the TIP is very different from slowly applying a force with a winch to a branch to measure attachment strength of branches, indicating that future experiments should consider applying forces to the TIP that would mimic the forces applied during an ascent.

Is that tie-in point safe to use? *(continued from front)*

This work wouldn't have been possible without a John Z. Duling grant from TREE Fund, which paid for the Straightpoint, LLC load cell. One of the limitations of the data collected at the ITCC is that the TIP was atypically large (which was a necessary safety precaution when more than 60 competitors would be ascending during the event). To address this limitation, and using the same Straightpoint LLC load cell, I am currently measuring forces during ascents on TIPs of typical size. And I plan to repeat those measurements when the trees are leafless to see how much of an effect the leaves have on damping the bounce motion of the TIP. With funds from the Duling grant, I also purchased two Straightpoint LLC "Impact Blocks"—arborist rigging blocks with built-in load cells—to measure forces in rigging systems, which I have been doing this summer. I think these projects, and others I've worked on that TREE Fund has previously supported, will help arborists work more safely, and I'm grateful for TREE Fund's support.

You can find more details about measuring forces during the 2017 ITCC in the following publications:

Kane, B. 2018. Loading experienced by a tie-in point during ascents. Urban Forestry & Urban Greening 34:78-84.
Kane, B. 2018. Understanding the likelihood of failure of an anchor point during an ascent: Part II. Arborist News 27(2):56-57.
Kane, B. 2018. Understanding the likelihood of failure of an anchor point during an ascent: Part I. Arborist News 27(1):58-60.

Dr. Brian Kane is the Massachusetts Arborists Association Professor of Commercial Arboriculture at the University of Massachusetts - Amherst. He has published over 50 scholarly papers, most of them have considered topics in arboricultural biomechanics and tree worker safety. He previously served on the ISA's Board of Directors and currently chairs the Nominating and Elections Committee. Before joining academia, he worked as a production arborist and he maintains his ISA Certified Arborist credential. He has competed in several regional tree climbing championships, placing 4th in New England in 2006.

Behind the Research: Meet Dr. Brian Kane

It's the first day of school at the University of Massachusetts, Amherst, and Dr. Brian Kane is back from sabbatical. Amid the flurry of campus activity, Dr. Kane takes a break to talk about his background and work with me. Dr. Kane, the Massachusetts Arborists Association Professor of Commercial Arboriculture at UMass Amherst, is a leading figure in arboricultural biomechanics and tree worker safety, focusing his research on tree failure and gear failure. With his unassuming, casual manner, it's surprising to know that he is one of very few people who study this complex area of the physics underlying tree failure and arboricultural practices like pruning, cabling, rigging and climbing.

Brian grew up outside of New York City and remembers his early interest in trees was piqued by his dad's Audubon Tree Guide book. He ran a landscaping business as a kid and loved climbing for a local municipal tree crew, but it took a degree in Political Science and an unsatisfactory desk job before he realized that the one constant throughout his life was that he liked trees. So he enrolled at UMass Amherst for a masters in Arboriculture and later a PhD, and he hasn't looked back since.

At the start of his academic career, Brian was interested in the strength loss formulas that predicted the likelihood of tree failure based on how much decay existed in the trunk and branches. The formulas were theoretically sound, but had not been tested for reliability in real life scenarios. What he discovered was that the formulas did not take enough variables into account for such a complex assessment. His work played a role in the development of ISA's tree risk assessment qualification (TRAQ), which has helped to make the risk assessment process more objective.

Brian's current work is focused on arborist safe work practices where there is a deficit of research. Specifically he's exploring the forces that occur (1) when a climber ascends into a tree and (2) in different parts of a rigging system. Because there are so many variables that affect the likelihood of tree failure and many different climbing and rigging techniques and tools, it's virtually impossible to come up with a formula for the safest way to climb or rig every tree. Dr. Kane sees his work as laying the groundwork for safety improvements by helping us understand the physics underlying rigging and climbing. This knowledge allows us to identify the key points or variables for improved safety or reducing the likelihood of failure.

As you might imagine, conducting arboricultural biomechanics research involves everything from people climbing trees to crunching physics and math equations. Dr. Kane emphasizes that his work is a collaborative effort, and he is grateful for all the help from his students, alumni, colleagues in the university's Engineering school, etc. And he's also happy to use himself as a test subject – just another reason to continue climbing trees after all these years.