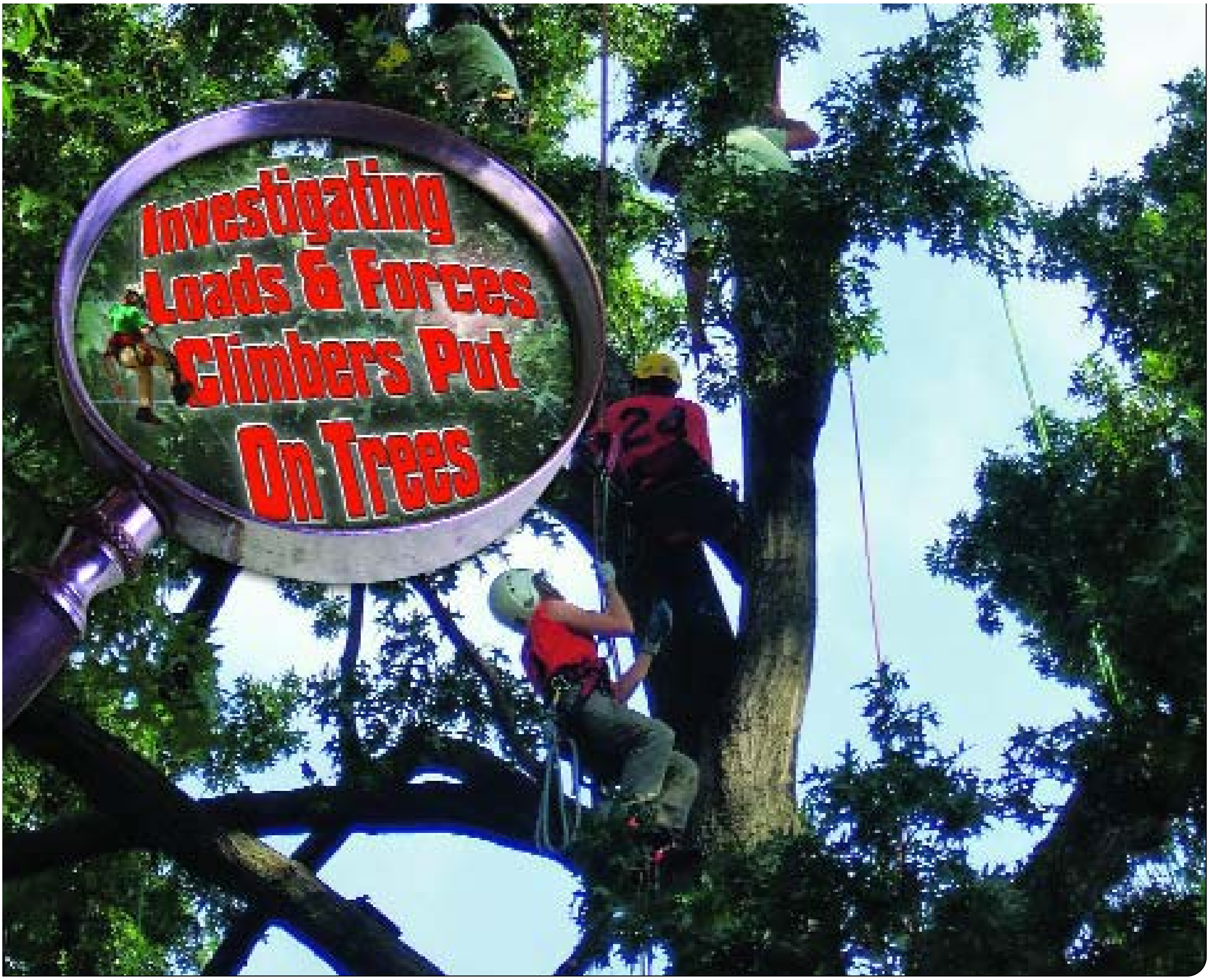

During the work climb event in a climbing competition, all climbers have to carry out a series of tasks while anchored at the same branch in a tree. Their different climbing styles, ropes and friction knots provide a wealth of data for studying the loads generated at the anchor point. Photo courtesy of Andreas Detter.

By Ted Shoemaker

Arboricultural work carries a high risk of injury. The British Health & Safety Executive (HSE), which is their version of OSHA, estimates that fatal and major incidence rates for arboriculture are at least double those of the construction industry. Studies carried out in the U.S. have rendered a similar picture. A number of European arborists are taking measures to reduce these dangers in several aspects of the daily work in the industry, including a particular focus on the stresses climbers and rigging put on trees.

The threats are particularly acute in rigging operations used in the dismantling of trees, when it is dangerous or unwise to allow cut sections to fall freely. Rigging methods have developed in recent years from "traditional" techniques, which utilized ropes in conjunction with only the natural features of the tree, to more advanced techniques that, in addition to rope, use a wide variety of specially designed tools and equipment.

During a rigging operation, the ropes, blocks, pulleys and the tree itself interact in complex ways that are not fully understood. Concerns have been raised that some practitioners in the industry may be using equipment and techniques without a full appreciation of either the forces generated or the limitations of the hardware and/or tree. The loads generated are not easy to quantify and can vary dramatically, depending not only on the mass of the section and the rigging set-up, but also on the tree's species and condition. The same is true for the strength of rigging systems, which depend on the structural integrity of their components as well as their appropriate configuration.

In view of this, the Forestry Commission of Great Britain and the HSE, as part of an Injury Reduction Program, granted a contract in 2006 for the assessment of rigging methods used in the U.K. Principle contracting firms were Treevolution Ltd of the UK and Brudi & Partner TreeConsult in Germany, but they were supported throughout all work phases by Chris Cowell from Treemagineers, (an association of working arborists based in Scotland that strives to develop techniques, safety practices and, occasionally, products for tree care operations) and Paul Howard from ArBO, a German tree care company.

The rigging research comprised a review of available literature and both laboratory and field tests to collect information on a number of issues related to carrying out a safe rigging operation, such as the strength of branches used as temporary anchor points in trees. Because of the scarcity of information available when the study started, winching tests were performed on standing trees. Branches and limbs up to 12 inches in diameter were loaded to fracture. Various mechanical properties were determined by analyzing the data generated.

Financing provided by the TREE Fund helped to extend the scope of this study, making additional tests in the laboratory possible, according to Andreas Detter, principal with Brudi & Partner TreeConsult. "Several other researchers are currently looking into this matter, and it seems that our knowledge of natural anchor points will be much more extensive in the near future," says Detter.

The researchers also recommended procedures for visually inspecting a tree for possible dangers, and for an estimation of the weight of sections to be cut. There were also evaluations of previous data on the weakening of rope because of knots made when it is attached to logs or stems. This data had been acquired in a joint project by Samson and ArborMaster. In that context, they also recommended that rigging systems be designed so that the rope is the weakest link.

"In the case of failure of an item of equipment other than the rope, the rope could turn any failed hardware component into a deadly projectile. That is not to say that the recoil of a failed rope is without risk, but it may well be the lesser of two evils," state the authors of the rigging research in their final report (soon available at www.hse.gov.uk and www.tree-consult.org).

Arborist safety is a matter of primary concern to Detter, who participated in the British study. In a subsequent study, Detter investigated the strength of used rigging ropes. Arborists usually attempt to determine whether a rope's strength is compromised by visually inspecting ropes for signs of defects. Yet, when comparing the results of such inspections to the actual strength lost by 20 used rigging ropes, no reliable correlation between the state of the rope and strength could be found. It seems that an appropriate estimate of strength is possible only through keeping track of the load history. That is why it is important to incorporate sufficient safety factors and discard ropes that were exposed to excessive forces, especially shock loading.

Along with Chris Cowell of the

Chris Cowell with the TreeQinetic® forcemeter, positioned at the anchor point during the ITCC work climb event in Saint Louis. Photo courtesy of Andreas Detter.

An example of a climbing system where two sides of the system are separated. Photo courtesy of Chris Cowell.

From left, Chris Cowell, Lothar Göcke and Andreas Detter. Göcke and Detter are holding the load cell/ forcemeter used to measure anchor loads. Photo courtesy of Melissa Duffy.

An example of a climbing system with a single point of attachment to the harness. Photo courtesy of Chris Cowell.

Treemagineers, Detter also took advantage of the recent International Tree Climbing Championship at St. Louis to make a study of climbing forces exerted by climbers on anchor points in trees.

"The setting was ideal. The 50 climbers from different continents, all of whom volunteered to have their climb monitored, created a wealth of data based on a variety of different climbing styles, ropes and friction knots. And all the action was confined to a single tree," says Cowell.

They were supported by Lothar Göcke of Argus Electronics, Germany, who provided all the instrumentation and operated it. They used 1) a load cell (forcemeter) to constantly measure the forces borne at the climbing anchor point, and 2) a high resolution strain gauge (elastometer) to measure deformation in the marginal fibers of the branch serving as the main anchor point. Both instruments transmitted their data to the ground by radio.

Also, Ted McLaughlin of McLaughlin Tree Service of Memphis, Tennessee, used a digital camcorder to record climber actions that led to loads and the tree's reaction to them. All climbers were also

An investigative record

Chris Cowell and his colleague from Treemagineers, Mark Bridge, already have an impressive history of investigating topics related to arborist safety. They played a major part in the rigging research, and made several investigations on safety issues. In a recent study, they looked at the strength of carabiners when loaded in two suboptimal configurations: 1) girth hitched around a branch or stem for work positioning, and 2) multiple or wide attachments within the top of a carabiner (see illustration).

While these configurations are not approved (and sometimes specifically prohibited) by manufacturers, some climbing arborists use equipment in

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An example of multi-point wide loading of a carabiner. Photo courtesy of Chris Cowell.

weighed while they were still wearing their gear in order to compare masses and correlate them to the forces exerted. The data collection was sponsored by TCIA members Dwayne Neustaeter of Arboriculture Canada Training & Education, Ltd. and Scott Prophet of North American Training Solutions.

"We monitored the loads that 50 climbers, male and female, generated at the anchor point during the work climb event," says Detter. "The results seemed reassuring to us: Only in very few cases, more than 1.6 kN was recorded, equal to about 160 kg mass (350 pounds) – that's about the weight of two average persons. Many climbers hardly put more force on the anchor point than their own body weight: the peak force for one female climber exceeded her body's weight by as little as 16 percent; one male competitor added only 25 percent to his weight. Great peaks occurred when climbers suddenly stopped in the course of a jump or traverse, or as someone occasionally slipped off a wet branch. Those are scenarios Chris and I would like to study in more detail."

The TreeQinetic® strainmeter used to record a branch's reaction when used as an anchor point. Photo courtesy of Andreas Detter.

Detter and Cowell are now seeking funding for the evaluation of the St. Louis study. This should 1) enable a comparison of the information already available on the strength of branches to the typical loads in standard climbing situations; and 2) determine peak loads generated from particular climbing actions. This information can result in recommendations for greater arborist safety and may pave the way for future studies, especially with regard to forces generated from fall/slip scenarios in a tree.

Ted Shoemaker is a freelance writer living in Germany.

Investigative history

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these configurations daily. For alternative solutions to avoid misconfigurations, visit Treemagineers Web site at www.treemagineers.com.

Cowell also made a study of ascent and ascenders. He has systematically identified different phases of ascent and determined the likely hazards for arborists. A large test series has studied the compatibility of ascenders with their neighboring components. The results of those test and all Treemagineers testing can also be found on their Web site.

Earlier, Bridge looked at forces that occur if a climber slips during ascent on an access rope. This led two other arborists to investigate the effect that new high-molecular weight fibers, such as Dyneema (a strong polyethylene fiber by a company called DSM) or Spectra (Allied Signal's Spectra® Fiber), would have in such cases. Jelte Buddingh and Christian Kruck found that Dyneema rope has the advantage of being strong, low stretch and one-third lighter than the more commonly used polyester ropes. When knotted however, Dyneema broke under a lesser weight than did polyester, and it lost more of its strength after shock-loading events.

Bridge has also been very active in developing user-friendly protocols for arborists in the field. His work has resulted in profusely illustrated pocket guides in German and English for the systematic analysis and processing of both risk assessment and rescue scenarios.

At right, Risk Assessment and Rescue pocket guides developed for field workers by Mark Bridge. Photo courtesy of Chris Cowell. Photo courtesy of Treemagineers.