89th Annual Conference
Toronto Ontario
AREA Sessions

Presentation Title
Does Taper Affect Bending Stress at the Base of Branches?

Author
Gregory A. Dahle, Ph.D., West Virginia University

Presentation Summary

Trees provide valuable benefits in urban areas, yet there are costs associated with urban trees. These costs include monies spent on transplanting, developing and maintaining trees, as well as risks associated with failures of branches, trunks or roots. Tree failures can harm objects such as houses, cars, or powerlines. The current tree risk assessment standards address how to evaluate risk based on the likelihood of a failure occurring and the severity of the consequences. Determining the likelihood of a failure can be difficult, as an arborist must predict instability of a tree or tree part. In the case of branches, stability can be a reduced due to the presence of cracks, decay, codominant branching, poor taper or weakly attached branches. Yet, defining a weakly attached branch can be difficult.

As wind, snow or ice builds up along branches; bending moments are created which increase proximally towards the branch base. Bending stress (force per unit area) is a function of the applied load * the bending distance (moment arm) divided by the moment of inertia or resistance to bending (a power function of the cross-section). Theoretic calculations applied a concentrated load at the center of gravity and thus maximum bending load should be highest at the point of attachment. Yet arborists report that often branches do not fail at their point of attachment, rather a short distance up from the base. This reported failure pattern is likely the result of the presence of a branch collar and taper which provides a larger moment of inertia to resist the bending load, thus reducing overall bending stress.

This presentation will discuss a study that measured taper along a series of branches and then applied theoretical loading. We measured 30 branches each from white pine (*Pinus strobus*), pin oak (*Quercus palustris*) and black maple (*Acer nigrum*). Branch diameter was measured every two cm (0.79 in), beginning at the branch collar and continuing for 50 cm (19.7 in). A theoretical fixed load was applied at a given length along the branch and bending stress was calculated at each 2 cm interval. Diameter was measure in both the vertical and horizontal directions to determine if a given location was circular or elliptical so as to apply the appropriate formula for the moment of inertia. The predicted location of maximum stress will be compared across the species to determine if pattern exist. This information may be useful to practitioners in understanding where branches fail and identify branches with poor taper at the base. Additionally, this may be useful to modelers when investigating how branches fail or withstand static or dynamic loading events.