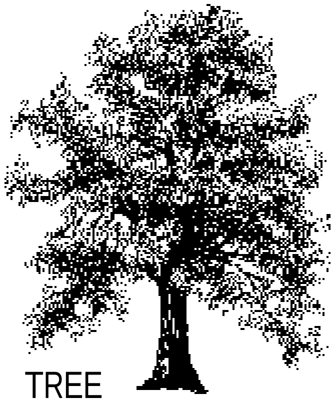

TREE
BIOMECHANICS
SERIES

Neutral Plane Faults & Stem Strength

by Dr. Kim D. Coder, Professor
University of Georgia, Sept. 2000

In storm damage and tree failure assessments, estimating residual strength of damaged trees is difficult and filled with complex, dynamic interactions between the soil, tree, and environment. To help tree specialists appreciate tree biomechanics, this publication was developed to present the maximum relative strength values for two unique, ideal situations -- neutral plane faults leaving two stem halves and four stem quarters. This theoretical view can help better understand certain mechanical forces and resistances.

The relative strength of stems with two different types of "perfect" neutral plane faults are presented in this publication. Stems split in half and in quarters are compared in relative strength to solid stems of the same diameter. Figure 1 & 2 provide a descriptive review of the problems and associated calculations.

Results

A stem with a longitudinal split (leaving two equal halves) along the neutral plane is 28% percent as strong as a solid stem, when bent in the same direction as initiated the fault or perpendicular to the neutral plane. The same faulted stem of two halves have the same strength as a solid stem when bending force is applied parallel to the neutral plane. The two half stems represent only 64% of the relative torsional strength (twisting strength) of a solid stem. Relative strength in resisting bending perpendicular to the neutral plane is 44% of the torsional strength, while relative bending strength parallel to the neutral plane is 1.56 times the torsional strength of the two half stems. If the stem is split into quarters, the relative bending and torsional strength of the four piece stem is 28% of a solid stem. Note that interactions between stem longitudinal sections are not considered, with stem portions treated as completely separate (clean breaks) units except for adjacentcy (proximity) effects. The relative strength loss was taken at a cross-section where the portions were completely separated.

Conclusions

Stem strength to resist bending and twist quickly declines (to 28% in bending and 64% in twist) when force is applied perpendicular to the neutral plane in stems which have developed neutral plane faults. Neutral plane faults lead to catastrophic failures in stems.

The University of Georgia

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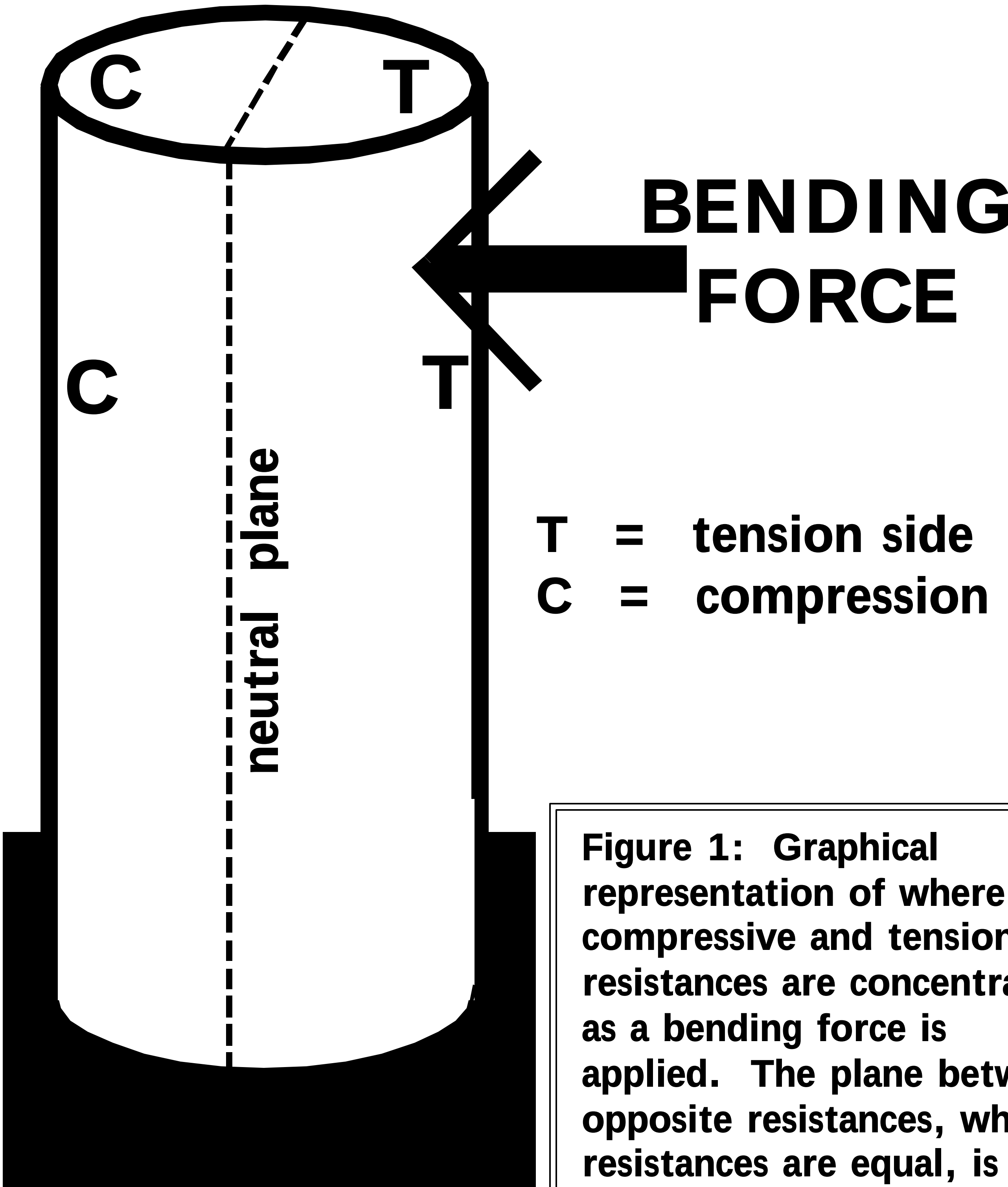


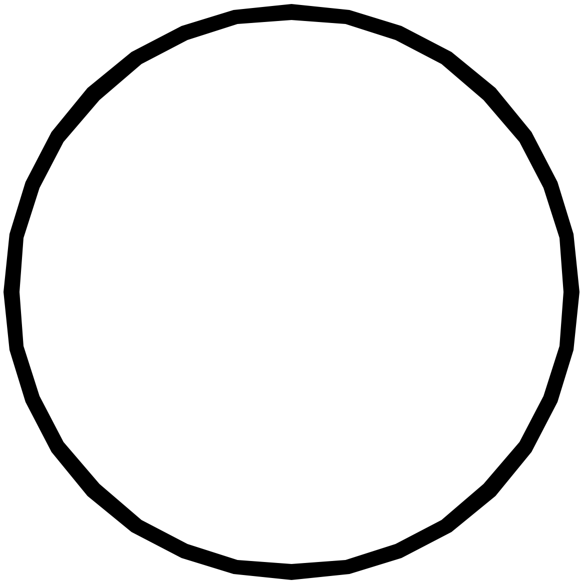
T = tension side
C = compression side

- top side of deflection / windward side in tension under bending force

- bottom side of deflection / leeward side in compression under bending force

Figure 1: Graphical representation of where compressive and tension resistances are concentrated as a bending force is applied. The plane between opposite resistances, where resistances are equal, is termed the "neutral plane," and is the location of one type of catastrophic stem fault.

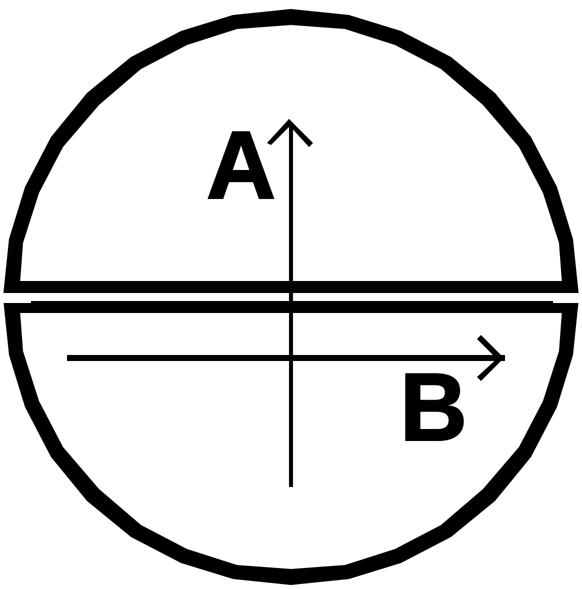
stem cross-sections



Solid Stem Strength

relative bending strength =
$((B \times (\text{STEM DIAMETER})^4) / 64$

relative torsional strength =
$((B \times (\text{STEM DIAMETER})^4) / 32$

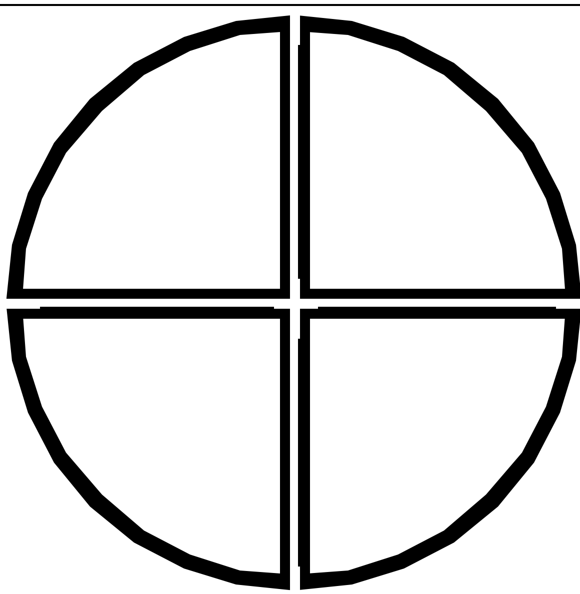


Neutral Plane Failures -- Two Half Stems

relative bending strength in direction A =
$(0.0137) \times (\text{STEM DIAMETER})^4$

relative bending strength in direction B =
$(0.049) \times (\text{STEM DIAMETER})^4$

relative torsional strength =
$(0.0628) \times (\text{STEM DIAMETER})^4$



Neutral Plane Failures -- Four Stem Quarters

relative bending strength =
$(0.22) \times (\text{STEM RADIUS})^4$

relative torsional strength =
$(0.44) \times (\text{STEM RADIUS})^4$

Figure 2: Graphical definition of calculations.