# HANDSHEET PROPERTY PREDICTION FROM KRAFT FIBRE, AND WOOD TRACHEID PROPERTIES IN ELEVEN RADIATA PINE CLONES

**R. Paul Kibblewhite*, Robert Evans** and Mark J. C. Riddell***

***PAPRO New Zealand, Forest Research Institute, RO3030, Rotorua, New Zealand**

****CSIRO Division of Forest Products, Private Bag 10, Rosebank MDC 3169 Clayton, Victoria, Australia**

**EXTENDED ABSTRACT**

Patterns of variation in density, tracheid cross-section dimensions and kraft pulp fibre dimensions are estimated and the predictability of handsheet properties evaluated using eleven 16-year-old clones of radiata pine. Two trees of each of 10 clones (20 pulps), and the bulked sample of four trees of an additional clone (two pulps) made up the samples used in the analyses.

Whole-tree and breast-height estimates of wood tracheid cross-section dimensions were measured using SilviScan, an automated wood micro-structure analyser. Tracheid dimensions were determined for pith-to-bark strips taken at breast height (1.4 m) and at 5.5 m intervals up each tree. The kraft fibre cross-section dimensions of each pulp were measured by image analysis of sections of embedded fibres. Tracheid and fibre properties evaluated included width, thickness, perimeter, wall area, coarseness, wall thickness, length, and selected property ratios. Fibre and tracheid properties were compared to handsheet properties at 500 PFI mill rev, a tensile index of 100 N.m/g, and an apparent density of 730 kg/m$^3$.

Regression of whole-tree property estimates on breast-height wood properties gave very high coefficients of determination ($r^2$) ranging from .83 for tracheid wall thickness to .91 for tracheid perimeter. There was no significant correlation between wood density and tracheid coarseness, or between tracheid perimeter and wall thickness, indicating that important tracheid properties such as perimeter and wall thickness may be independently selected in tree improvement programs. Although the within-clone variance in average growth rate (as indicated by tree volume) was similar to that between clones, the within-clone variation in tracheid characteristics was much smaller than that between clones. Intraclass correlation coefficients ranged from .93 for tracheid wall thickness to .99 for tracheid perimeter, while those for tree volume and mass, as estimated from the sample strips at all heights, were not significant. Furthermore, the shapes of the frequency distributions of wood properties were very similar for trees within a clone. The high intraclass correlation coefficients for wood properties indicate that the number of core samples required to assess wood quality in clonal plantations would be much less than that required to assess wood production rate.

Breast-height wood properties were strong predictors of pulp fibre properties, especially fibre coarseness ($r^2$=.74) and fibre perimeter ($r^2$=.84). Whole-tree chip basic density was strongly correlated with breast-height core density ($r^2$=.86). When the properties of trees within each clone were averaged, giving two radial breast-height cores per clone, the results improved as expected (coarseness: $r^2$=.82; perimeter: $r^2$=.91; chip basic density: $r^2$=.92). It is concluded that whole-tree properties and kraft pulp fibre properties such as perimeter and coarseness can be efficiently predicted from the wood microstructure of breast-height core samples.

Handsheet apparent density and light scattering coefficient, and tensile, tear and burst strength, are predictable from the kraft fibre or wood tracheid (both whole-tree and breast-height) wall thickness and perimeter, and kraft fibre length combinations. Other useful handsheet property predictors are the fibre width/thickness ratio, the fibre or tracheid perimeter/wall thickness ratio and fibre length combination, and the chip or wood basic density and fibre length combinations.

A minimal level of pulp refining (in this case 500 PFI mill rev) is the most meaningful basis of comparison for the prediction of handsheet properties from tracheid and unrefined kraft fibre dimensions.

- The width/thickness ratio of the unrefined dried and rewetted kraft fibres is a moderate to good predictor of handsheet apparent

density ($r^2$=.59) and tensile ($r^2$=.49), tear ($r^2$=.72) and burst ($r^2$=.71) index. Inclusion of fibre length in the four relationships improves the prediction of apparent density only ($r^2$=.66). Such an effect is explained by the major influence of sheet structure in determining apparent density, and the major influence of bonding and bonded area in determining strength properties. Corresponding wood tracheid width/thickness ratios are generally poorly correlated with handsheet properties, as expected.

- Kraft fibre or wood tracheid wall thickness and perimeter, and fibre length together are moderate to good predictors of handsheet apparent density ($r^2$=.62-.79), light scattering coefficient ($r^2$=.43-.47), and tear ($r^2$=.72-.80) and burst ($r^2$=.54-.67) index.
- The wood tracheid properties of wall thickness, perimeter, and kraft fibre length together are good predictors of handsheet tensile index ($r^2$=.69-.75). Tensile index is however poorly predicted by these three kraft fibre properties ($r^2$=.23), probably because of some anomalous kraft fibre wall thickness values.
- Chip or wood basic density, and kraft fibre length together are good predictors of handsheet apparent density ($r^2$=.73-.83) and tensile ($r^2$=.65-.76), tear ($r^2$=.78-.81) and burst ($r^2$=.68-.82) index.

With the comparison base 730 kg/m3 apparent density, handsheet light scattering coefficient is well predicted by kraft fibre or wood tracheid wall thickness and perimeter together with fibre length ($r^2$=.52-.86). Also by fibre length and chip or wood basic density ($r^2$=.75-.86). Light scattering coefficient is generally poorly predicted by fibre and tracheid properties with the comparison base 500 PFI mill rev.

With the comparison base 100 N.m/g tensile index, fibre and tracheid predictors of handsheet apparent density and tear index are similar to those identified at the 500 rev basis of comparison - the wall thickness, perimeter and length combination, and the chip or wood density and fibre length combination. Coefficients of determination are somewhat lower than with the comparison base at 500 rev PFI mill.