Final Report

Comparison of bending strength and stiffness of naturally tapered fence posts and lathe turned fence posts

Prepared by:

Paul A. Cooper, Tony Ung, Joseph Samson Morasse and Arnaud Nicollin
Faculty of Forestry,
University of Toronto
33 Willcocks St., Toronto M5S 3B3,
Ontario, Canada

Prepared for:

Osmose Inc.
Attn. Brad Burmeister

July 23, 2009

Introduction

Treated wood fence posts can be prepared from naturally peeled tapered posts, which retain most of the wood fibre, and especially the treatable sapwood or can be shaped (dowelled) on a lathe to present a uniform shape and diameter. This latter approach removes significant sapwood and it is expected that the dowelled posts will be less strong in bending because of the reduced section and will be less well treated, especially where more wood is removed (towards the butt of the log).

The purpose of the proposed study is to compare the bending strength and stiffness and the preservative treatment quality of posts prepared by the two approaches.

Methodology

Osmose/Spray Lakes delivered 100 lodgepole pine fence posts each of the two described types to our test facilities. Posts were all 7-feet in length and pointed ("pencil-sharpened") at one end. Posts were pressure treated with chromated copper arsenate wood preservative.

The posts were air dried to below the fiber saturation point moisture content when delivered. To simulate post performance in the ground, the butt sections (about 3') were submerged in water (test method B in the ASTM D 1306) until the region was at or above the fiber saturation point moisture content. At MC>FSP, wood is weakest and there is no further effect on strength at higher moisture content.

ASTM D 1036 (pole testing) tests were conducted using the machine test method whereby the posts were supported at both ends by wooden cradles (4" radius) and the load was applied at the ground line using a Zwick test machine (Figures 1 and 2). Before placing the posts on the test bench, the diameter at the butt, tip and loading point were measured, for the determination of the taper. Then they were placed in the cradles, with the most visible defect (knot or bark pocket) down. Deflection at the ground line was determined by the movement of the cross-head. The loading rate depends on the post length and diameter (see ASTM D 1306 section 22.1): 4.3 mm/min for the dowelled (diameter 3.3 inches) and 3.8 mm/min. for the peeled posts (average diameter 4.2 inches).

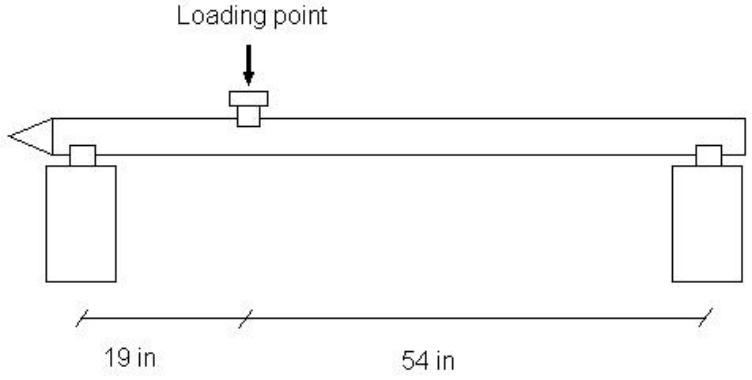

Figure 1: Test setup

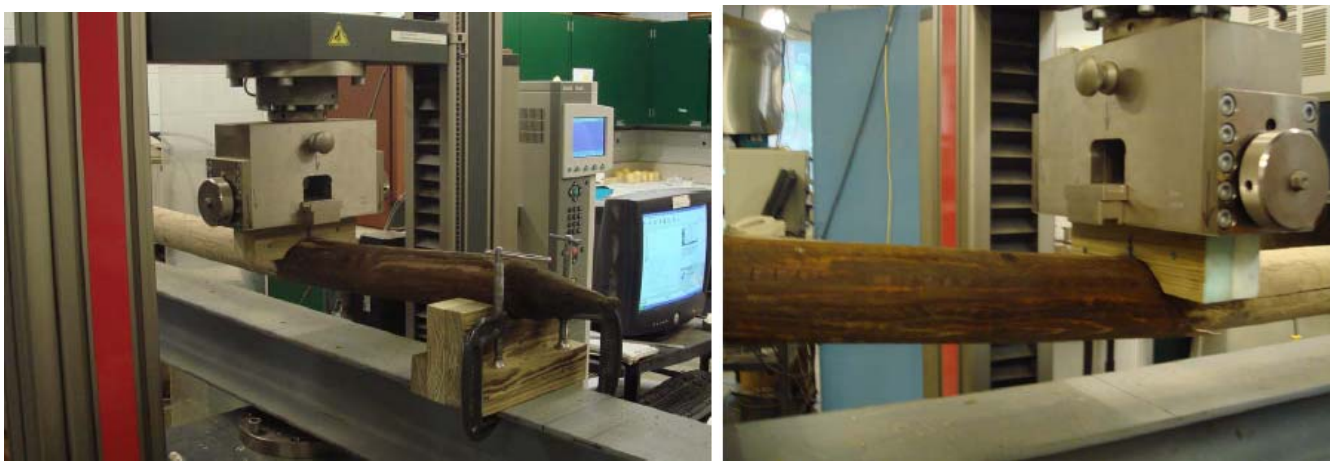

Figure 2: Post test setup in Zwick test machine

After failure, the posts were cross cut near the ground line and a sample taken for moisture content and preservative penetration determination.

Strength comparisons were made based on load at failure and deflection at the proportional limit, since for this study we are more interested in the load resistances of the two types of posts. Modulus of rupture (MOR) and stiffness (Modulus of elasticity - MOE), corrected for differences in dimensions and taper to provide a wood fiber stress were also estimated. These provide an estimate of fiber strength and stiffness and indicate the relative performance of the two types of posts if they had equal geometry (size and taper).

Penetration was determined by the average of the minimum and maximum penetration depth of CCA in the wood in each disc from the ground line area.

Results

Mechanical properties

Table 1 here shows the mechanical properties of both types posts, regardless on their shapes or moisture content. The cumulative distributions of load capacities for the two types of posts are shown in Figure 3.

It can be seen that with a slightly higher average diameter (4.2 inches vs 3.3 inches) the peeled posts had significantly higher maximum load capacities; in fact the resistance to loading was more than double that of the dowelled posts. The cumulative distribution curves (Figure 3) indicate that the 5^{th} percentile (a measure of the effective strength or reliability of the posts) was about 2500 pounds for the tapered posts and 1000 pounds for the dowelled posts.

Even though they were bigger, the tapered posts were slightly more flexible. The deflection at proportional limit for peeled posts is a bit higher due to a higher uptake in

moisture in the sapwood during soaking prior to testing. The dowelled posts were usually high in heartwood and did not absorb as much water on soaking.

The wood fiber characteristics (MOE and MOR were also estimated and the results are shown in Appendix A).

Table 1: Comparison of strength and stiffness of two post types as indicated by failing load and deflection in the elastic range

Post type	Failure load (lbs)		Deflection at proportional limit inches (mm)	
	Average	s.d.	Average	s.d.
Peeled	3325	576	0.808 (20.5)	0.090 (2.29)
Dowelled	1479	313	0.751 (19.1)	0.070 (1.78)

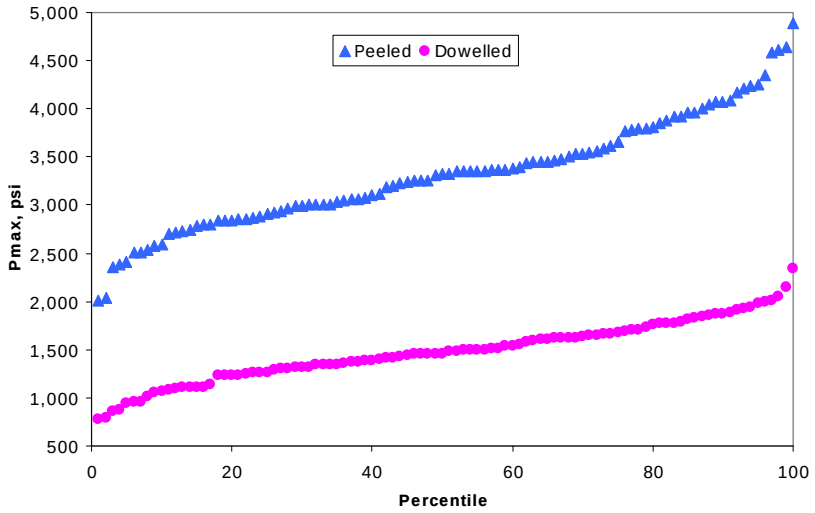

Figure 3: Cumulative distributions of load carrying capacities of the two types of posts

Treatment quality

The CCA penetrations of in the posts are summarized in Table 2.
Both post types were variable in quality of treatment, with some posts having no sapwood left and very little preservative penetration. The peeled posts were a better treated on average compared to the dowelled posts, and were more consistent (lower standard deviation). The average penetration was 0.61" (15.4mm) for the peeled tapered posts compared to 0.41" (10.4mm) for the dowelled posts. The minimum penetration per post was generally lower for dowelled posts (Figure 4 - all the minimum values are sorted by ascending penetration depth (mm)).

Table 2: CCA penetration characteristics of the two post types.

Posts	Percentage of treated wood		Penetration Inches (mm)					
	average	s.d.	Minimum		Maximum		Average	
			average	s.d.	average	s.d.	average	s.d.
Peeled	25.4	10.9	0.44 (11.2)	0.27 (6.8)	0.77(19.5)	0.33 (8.4)	0.61 (15.4)	0.29 (7.3)
Doweled	22.3	15.6	0.23 (5.8)	0.27 (6.8)	0.59 (14.9)	0.41 (10.5)	0.41 (10.4)	0.31 (7.9)

For 40% of the dowelled posts, there was a part of the circumference where the CCA penetration did not exceed 2mm deep, making them more susceptible to decay and sensitive to handling misuses that could remove the thin protective layer. On peeled posts, less than 5% of the peeled posts had this low penetration since less sapwood was removed by the peeling process. About 80% of the peeled tapered posts had minimum penetration greater than 5mm while dowelled posts had less than 50% of the posts with greater than 5mm minimum penetration.

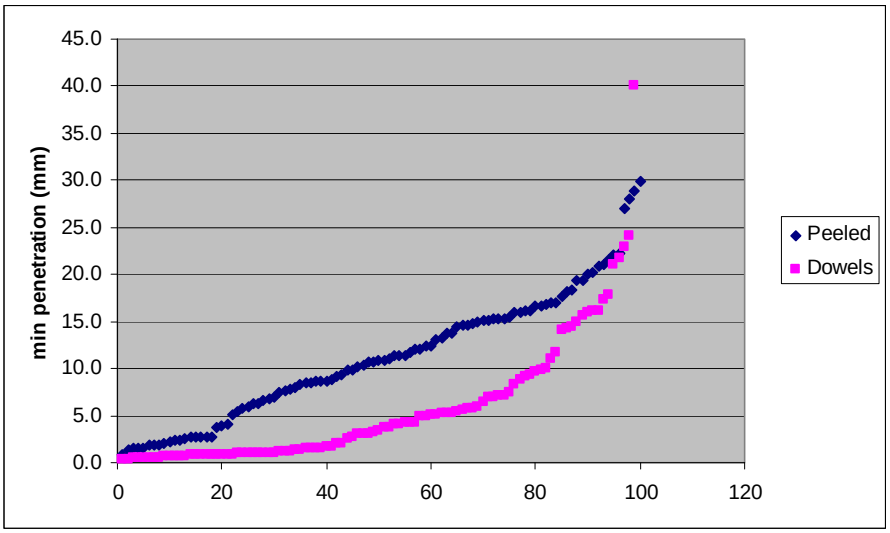

Figure 4: Minimum penetration measured in 100 posts of each type, plotted in ascending order

Photographs of the post sections near the ground line are shown in Figures 5 and 6.

Summary and Conclusions

One hundred lodgepole pine posts each of peeled tapered and dowelled posts were tested in bending. The larger peeled tapered posts (average diameter at ground line of 4.2 inches) were more than twice as strong as the dowelled posts (diameter 3.3") based on the load capacity when tested in bending. These posts were also more flexible (deflected more, probably as a result of the drier heartwood in the dowelled posts.

The quality of CCA penetration was higher in the peeled tapered posts also because of the greater amount of retained sapwood. Average penetration was about 50% higher in the peeled tapered posts and about 80% of these posts had minimum penetration greater than 5mm while dowelled posts had less than 50% of the posts with greater than 5mm minimum penetration.

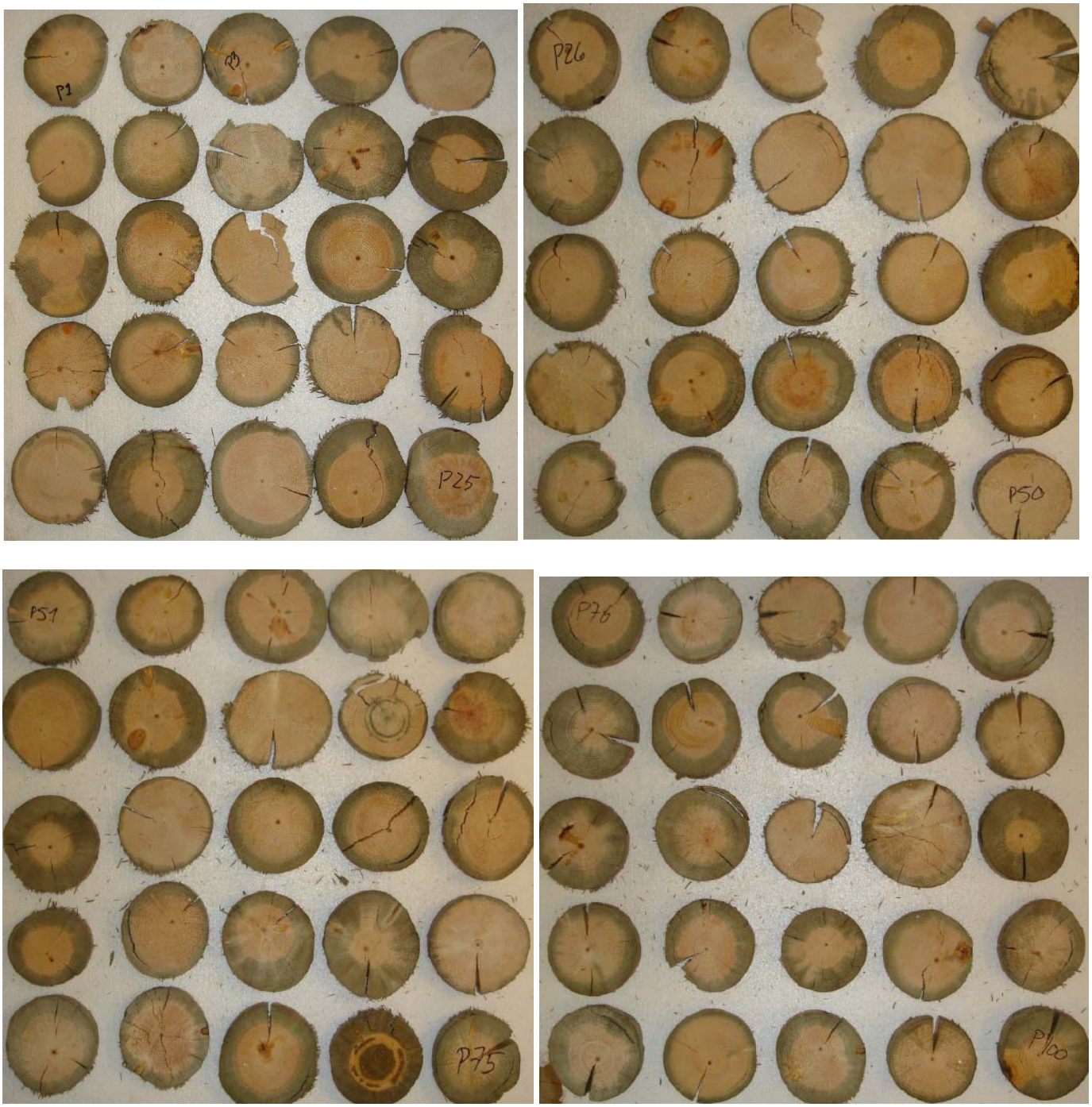

Figure 4: CCA penetration at ground line in peeled posts

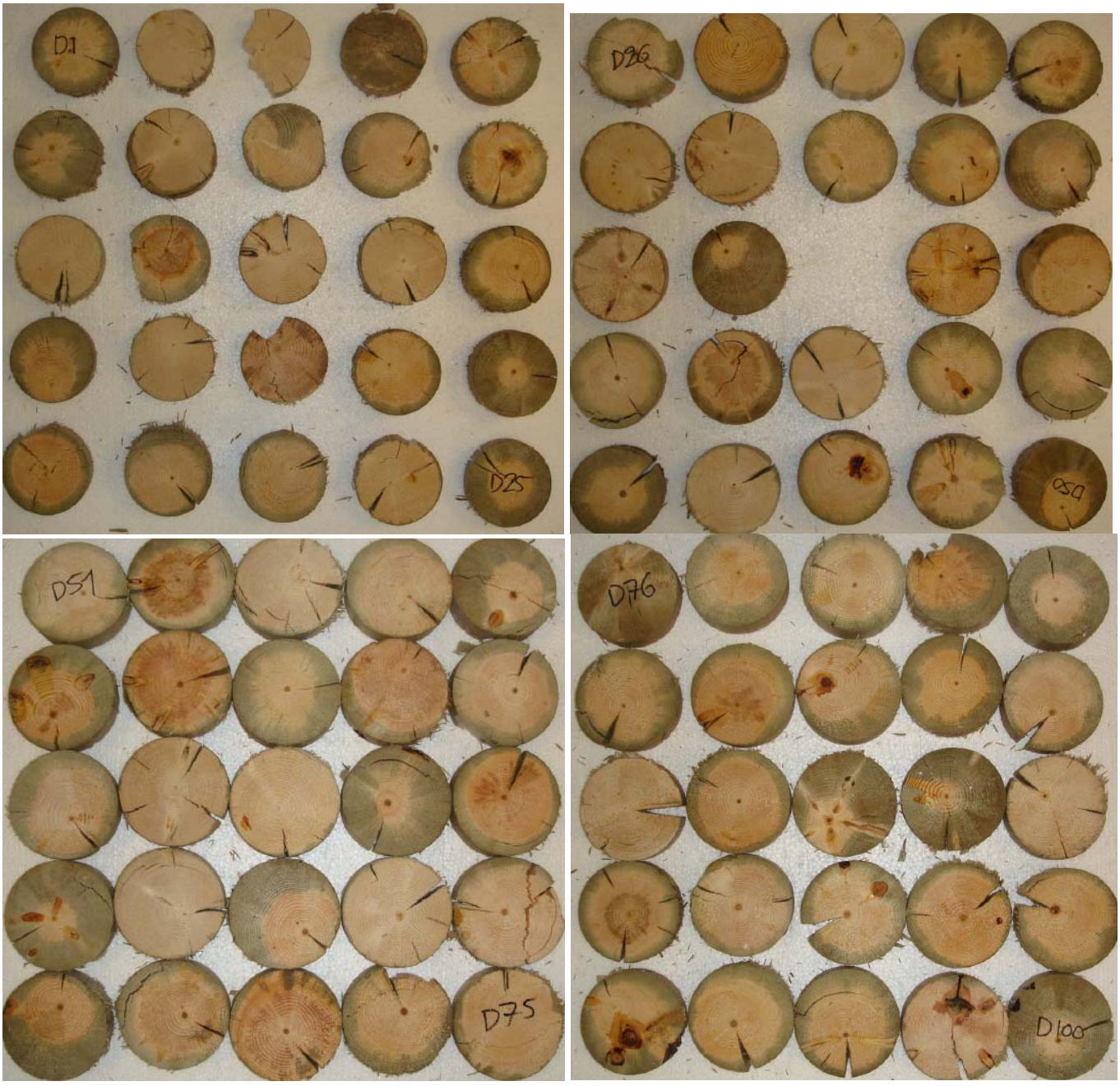

Figure 5: CCA penetration at ground line in dowelled posts