Optical measurement of local strains development in finger-jointed wood subjected to static and sustained loads

Boris Clouet[1], Lech Muszynski[2], and Régis Pommier[3]

[1]I2M/GCE - University of Bordeaux, Beynel Manustock – PGS group
[2]Oregon State University – Wood science and Engineering
[3]I2M/GCE - University of Bordeaux, Ecole Supérieure du Bois Nantes, Beynel Manustock – PGS group

Background

In this study the full field optical measurement techniques based on the digital image correlation (DIC) were applied to investigate the local strains development in wet formed finger joints in Maritime Pine logs.

Of particular interest is the load transfer at and around the finger tips, where the joint failure is typically initiated. New promising technology of creating finger joints in wet wood developed at the academy of wood science/university of Bordeaux is expected to reduce the effect of strain concentrations around the finger tips and thus improve the overall strength of the bond.

Materials and methods

Material was Maritime Pine. This wood was finger jointed on green wood, according to the standard EN385. This material was only upgradeable for pallet manufacturing. A one-component polyurethane adhesive was used. The final assemblies were dried, machined and tested. Specimens were stabilized at 12% Moisture Content.

The specimens were tested in static and sustained loads, using the Digital Image Correlation to investigate the local strains development. Scanning Electron Microscopy and X-Ray computed tomography were used to investigate the morphology of the bond and the behavior of the bond.

Results

Static load tests

- **Tensile tests associated to DIC measurement to investigate the bond behavior**

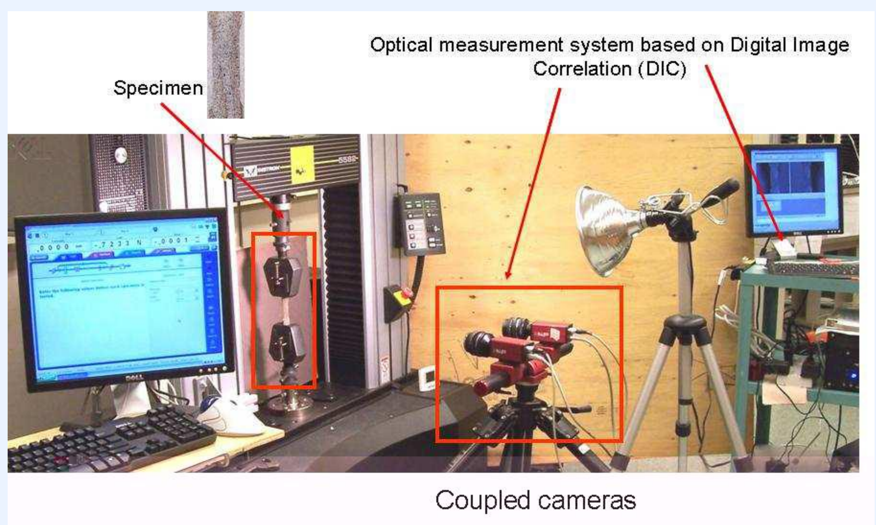

Figure 1: Static tensile test set up

- **The optical measurements revealed development of longitudinal strains concentrations**

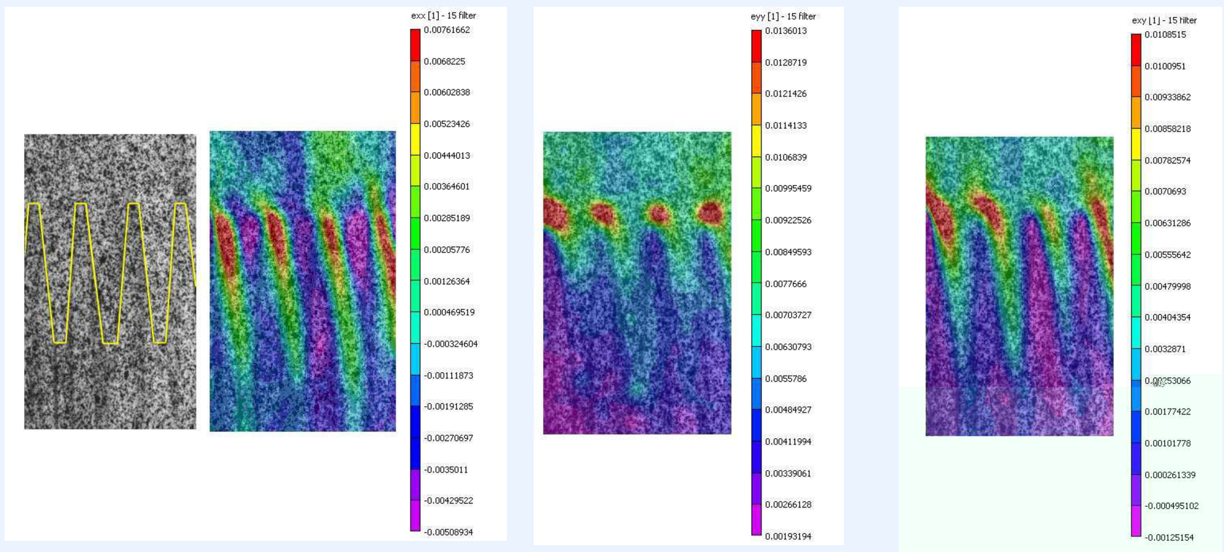

Figure 2: Respectively one of the tested assembly with the position of the finger joints and the exx, eyy and exy strain maps.

- **Longitudinal strain concentrations occur around the tip, there is a mechanical gap at the tip of the finger**

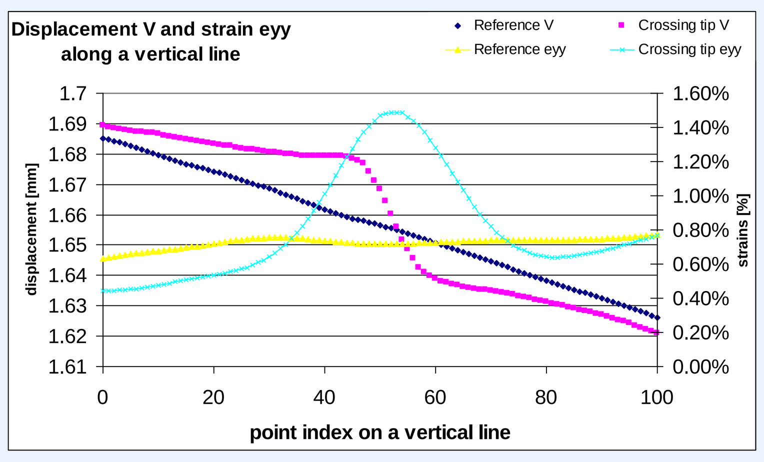

Figure 3: Displacement V(x=0) and strain eyy along a vertical line

Sustained load tests

- **Sustained load tests in tensile mode associated to DIC to investigate the bond creep behavior**

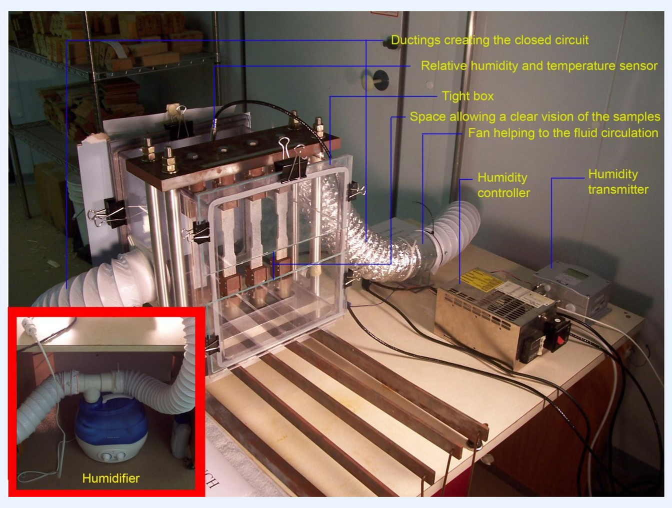

Figure 3: Sustained load test set up

- **Creep tests were carried out in tensile mode (RH 85%, 30%UTS), during 200 hours. Between 200 hours to 500 hours cyclic loading were carried out (cycles from 30% to 35% UTS and from 85% to 65% RH) (Figure 4b)**

- **Three types of measurements were made, on all the area and on two local tips. Like static tests, mechanical gaps occur at the tips (Figure 4a)**

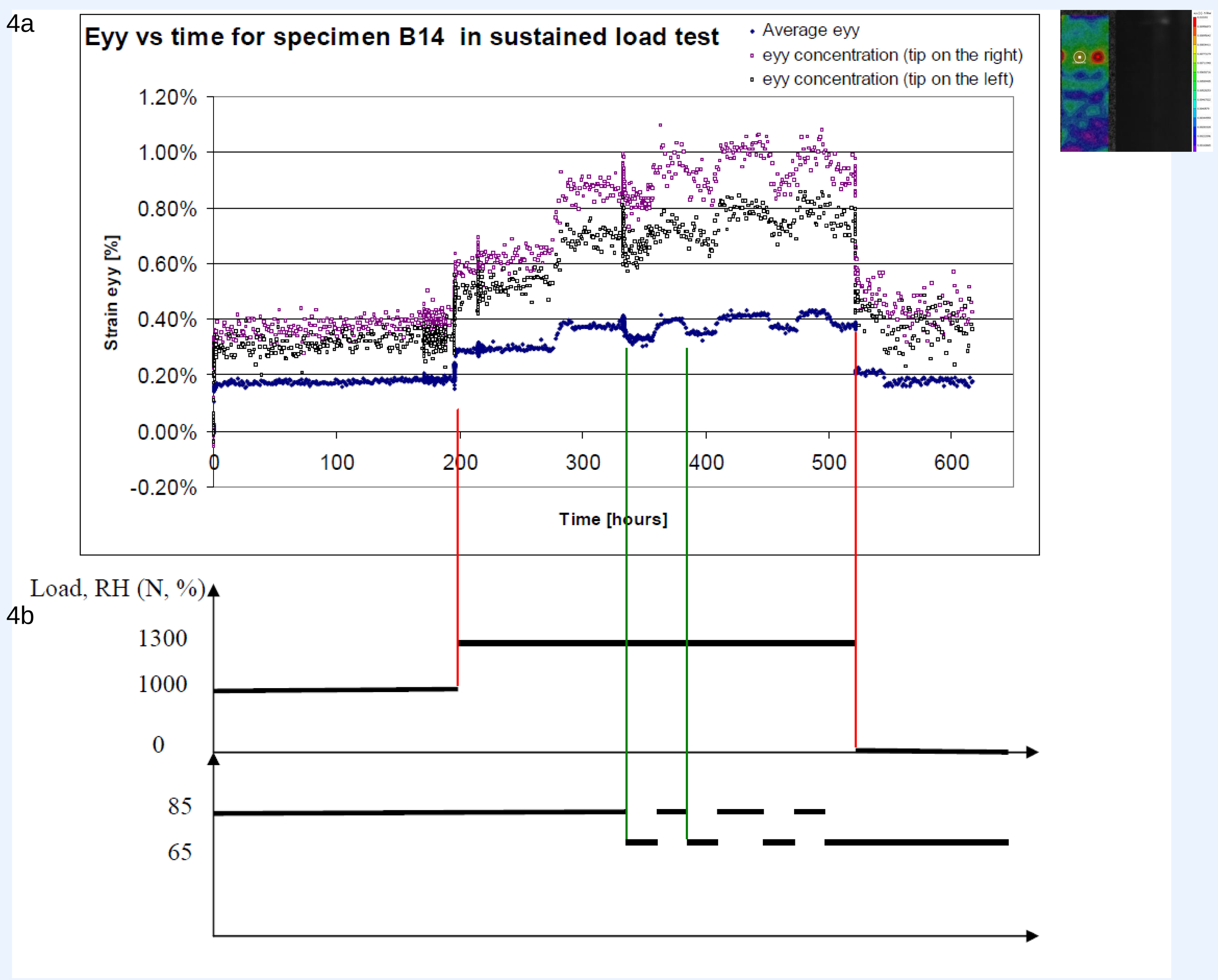

Figure 4a-b: Local behaviour of the tips in a specimen during a sustained load test

Morphological analysis of the bond line

- **X-Ray CT images of the tips were done**
- **Wood was compliant during the jointing process, there is a large concentration of adhesive along the bond line**
- **There is no gap on the bonding line around the finger, especially at the finger tip; the bond line is morphogically continuous**

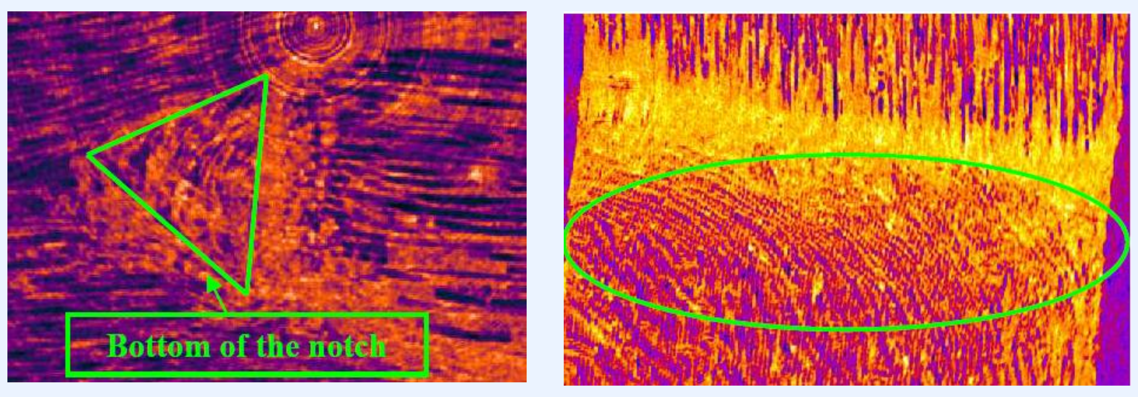

Figure 5: Close up of the finger tip and of the bond line sections

- **Scanning Electron Microscopy images of the tips were done**
- **There is a good penetration and concentration of the adhesive around the finger, especially around the tip**
- **There is no interface between the two pieces of wood; morphogically like a welding**

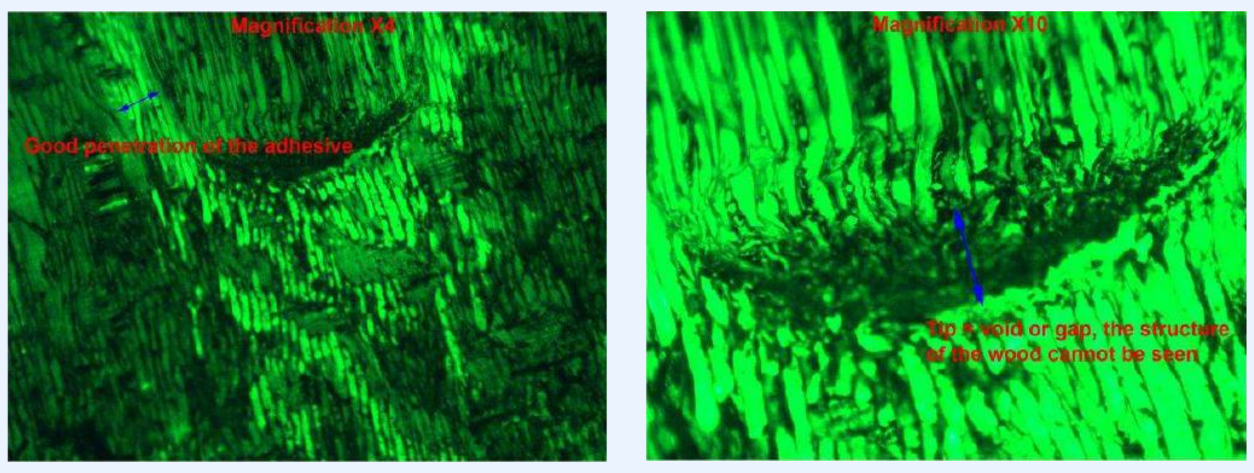

Figure 6: Microscopic images of one finger tip

Conclusion

Wood micro mechanic is essential to know behavior of adhesion and stress during drying and during mechanosorption effect.

- By Digital Images Correlation principle we observe measurement of displacements and strain concentrations in the specimen throughout the destructive test surface deformations
- By x-ray CT scans of the finger tip areas extracted from virgin spare specimens of the green bonded joints we observe minuscule gaps that focused the apparent strain concentrations.

Green finger jointing material will be able to be accepted to a non traditional adhesion; like a welding.