M.Sc. Wood Technology Master Thesis

Study of the interphase of glued hardwood load-bearing timber structure

Abstract

The Swiss forests produce a large quantity of hardwoods. Up to now, the manufacture and use of laminated glued elements in hardwoods in the field of load-bearing structures is very limited. This is partly due to the difficulty of gluing hardwoods. The bonding of glued laminate timber in hardwoods, is a more difficult operation given the following points. The coefficients of swelling and shrinkage of hardwoods are higher than those of conifers. This means that for the same variation in humidity the wood will result in a relatively higher stress in the bond line than with a conifer. Also, The mechanical resistance and stiffness of hardwoods is generally higher than for softwoods. It follows that, at equivalent stress, fracture will occur more frequently in the wood in softwood than in hardwoods and thus resinous timber will be credited with a higher percentage of wood fracture percentage. An improvement in the bonding process is necessary to ensure an increasing use of hardwood in the field of construction

Material and Method

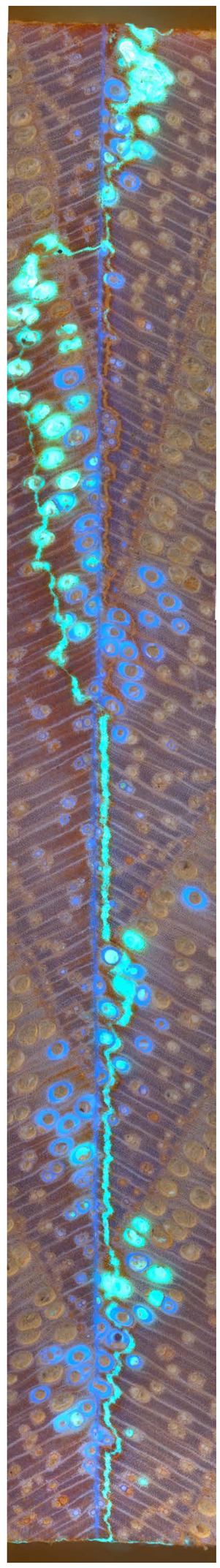
Two new methods of analysis have been developed in this work. The first method is a microscopic analysis technique by ultraviolet fluorescence of the fracture of glued wood samples. The second is a non-destructive technique by modal analysis coupled to a model FEM (finite element method) of inverse determination of the mechanical properties of the bonding joint. The microscopy analysis techniques makes it possible to visualize in a specific manner the distribution of the original glue line and to analyze, after rupture, the break line of an entire sample. This technique is interesting because it makes it possible to consider a complete sample without falling into the recurring problem of microscopy where only a part, not necessarily representative of the whole, is analyzed. The modal analysis technique is based on the principle that a change in the rigidity of a system results in a change in the resonant frequency of the system. It follows that a modification of the interface must also result in a modification of the resonant frequencies.

Results

The technique by UV microscopy allowed to developed an effective technique of analysis of the rupture of samples tested in longitudinal resistance to shear. This technique reveals important differences between the different adhesive systems tested. Using a modal analysis technique coupled with an FEM model, good agreement was obtained for glued elements between the observed resonance modes in the laboratory and the numerical model. However, this technique has proved inadequate to determine the mechanical properties of the interface. This is due to the fact that the relative influence of the rigidity of the interface on the resonance frequencies is very low compared to that of the density. In addition, as demonstrated by microscopy analysis, differences in interface stiffness between adhesive systems are significant only in humid climates. However, in this case, the density of the samples also varies strongly, which implies that a determination of the rigidity of the interface is then no longer possible precisely. This work allowed to highlight fundamental differences between the different adhesive systems commonly used in the wood industry. Thus it has been shown that the Aerodux 185 adhesives is capable of penetrating (completely impregnating) the wood cells on a few micrometer, thereby allowing a significant interpenetration of the adhesive with the wood.

Conclusion

This work has improved the knowledge of the wood-adhesive interphase behavior and allows a better understanding of the different adhesive systems in order to optimize their operation. Further research is needed to better understand the influence of the type of Primer and its concentration on the resistance of the adhesive joint in wet climate.



Fracture analysis of Ash wood glued sample; the original glue line is shown in dark blue, the breaking line is shown in green

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