Computational Wood Mechanics using the Material Point Method

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The material point method (MPM) [1] has developed over the past 25 years into a robust tool for computational mechanics. It has numerical features that recommend it for modeling of wood. For example, it can model complex, realistic structures, deal with realistic constitutive laws, model cracks and contact, and model wood-adhesive interactions. This talk will cover some recent developments in MPM and their application to problems in wood products.

Because MPM is a particle method, it is relatively straight forward to translate 3D X-Ray CT data directly into a realistic model for wood by converting voxels in the X-Ray data into material points in the computer model. A past project at Oregon State University [2] recorded X-Ray CT data for wood-adhesive bonds. The adhesives were tagged to allow segmentation of wood cell wall from adhesive thereby providing 3D data for adhesive penetration into wood cells. The previous project used MPM to model stresses and strains in those structures [2]. We have now also modeled penetration of the adhesive into wood cells using fluid mechanics. In brief, we started with X-Ray data, removed the adhesive, separated the two wood adherends, and restored the adhesive as a slab between the adherends. This entire structure was them compressed in an MPM model. The MPM predictions of penetration were compared to experimental results and showed good agreement. Note that the X-Ray data provided both a realistic structure for input to the model and experimental observations to validate the modeling. Figure 1 shows the initial MPM model (1A) and final state for the MPM model (1B and 1C; the top half is remove in 1B to see adhesive penetration). The modeling was for penetration of phenol formaldehyde (PF) resin into hybrid poplar [3].

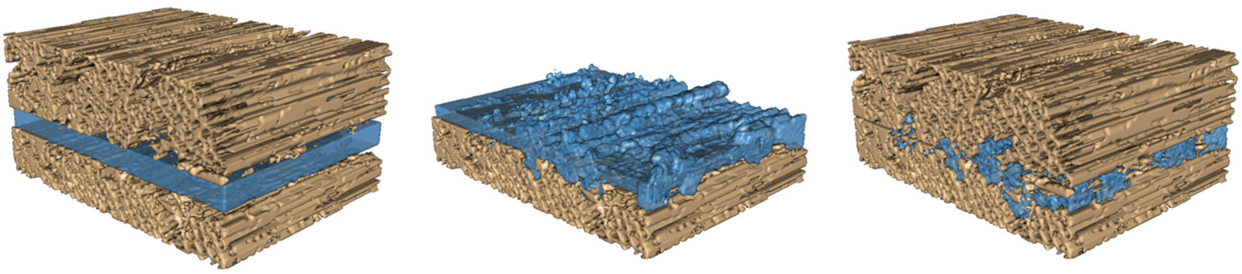

Figure 1: A. Initial model B Final result (top removed) C. Final result (full)

In addition to modeling adhesive penetration, MPM can model subsequent failure of the wood-adhesive bond using newly developed methods for anisotropic damage mechanics of an initially anisotropic material [4]. The damage mechanics methods have applications in many other wood failure problems such as modeling the tendency of cross-laminated timber (CLT) to develop cracks in all layers after relatively minor changes in moisture content [5]. Other wood applications of MPM include modeling of cutting [6] and failure of wood-working joints.

References

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