A New Macro Modeling Approach in Structural Analysis of Integrally-Attached Timber Plate Structures

Aryan Rezaei Rad[†*], Henry V. Burton[‡], and Yves Weinand[†]

[†]Laboratory of Timber Construction (IBOIS), École Polytechnique Fédérale de Lausanne (EPFL), Aryan.Rezaeirad@epfl.ch; Yves.Weinand@epfl.ch

[‡]School of Civil and Environmental Engineering, University of California Los Angeles (UCLA), hvburton@ucla.edu

The recent advancements in the robotic fabrication of engineered timber products are used to re-consider the oldest known method of wood-wood joinery, apply it in modern architecture, and provide an integrated design framework in free-form spatial timber plate structures (Figure 1) [1]. The structures are adaptable to a wide range of large-scaled 3D forms; nevertheless, there have been few systematic investigations of their mechanical characteristics.

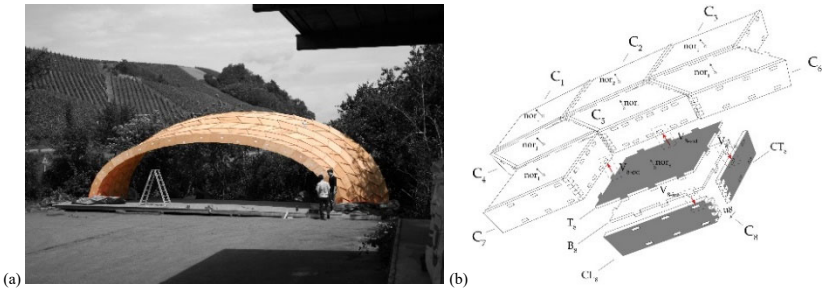

Figure 1: Integrally-Attached Timber Plate Structures; (a) Prototype, (b) Assembly Logic

Providing an efficient and practical-oriented mechanical models seems inevitable. In light of this, through avoiding plasticity governed shell and solid meshes, a novel modeling approach is proposed, where series of beam-column elements are used. This approach, which is referred to as the "macro models" remarkably enhances the efficiency of structural computations. Burton et al. [2] provided the application of such model in timber frames. Through the kinematic realization (Figure 2a-b), the macro models versus mesh-based shell FE models are shown in Figure 2c.

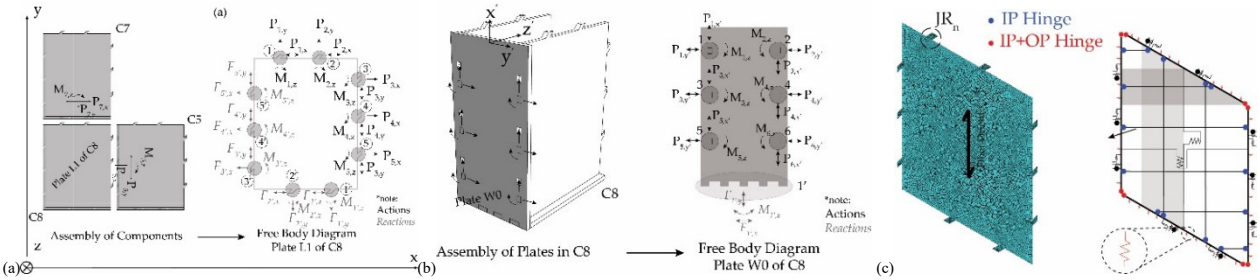

Figure 2: Free Body Diagram, Macro vs. FE models

The performance of an integrally-attached timber plate under In-Plane (IP) and Out-of-Plane (OP) load cases are demonstrated in Figure 3. The results are in line with the FE mesh-based solutions. The mode of deformation is well approximated in the macro model and it is close to the deformed shape simulated by the FE model.

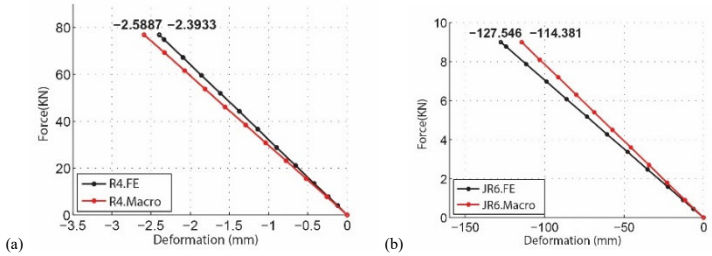

Figure 3: IP and OP behavior of Macro and FE models

References

[1] Robeller, C., Konaković, M., Dedijer, M., Pauly, M., Weinand, Y., 2017. Double-layered timber plate shell. Int. J. Sp. Struct. 32, 160–175. https://doi.org/10.1177/0266351117742853

[2] Burton, H., Rad, A.R., Yi, Z., Gutierrez, D., Ojuri, K., 2018. Seismic collapse performance of Los Angeles soft, weak, and open-front wall line woodframe structures retrofitted using different procedures. Bull. Earthq. Eng. https://doi.org/10.1007/s10518-018-00524-w

ISBN: 978-91-88898-64-7