Cracow University of Technology
Faculty of Civil Engineering
Building Vibration Laboratory

ul. Warszawska 24, 31-155 Kraków, Poland

This poster was elaborated within the Work Package WP7 – Communication and Dissemination of a European Horizon 2020 grant MEZEROE, grant agreement ID: 953157

Jarosław Chełmecki
jaroslaw.chelmecki@pk.edu.pl

Co-authors:
Arkadiusz Kwiecień
Klaudia Śliwa-Wieczorek

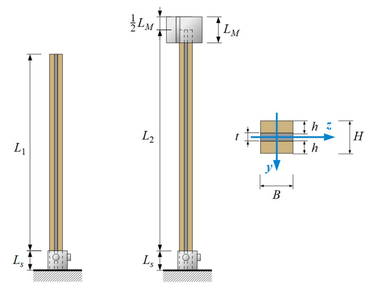
Determination of dynamic characteristics of timber elements with PU adhesives under small and large strains

BACKGROUND

This study investigates the vibration behavior of adhesively bonded composite cantilevers composed of two beech wood lamellae and a bondline made of various flexible polyurethane adhesives. While all cantilevers had constant height and cross-sectional dimensions, they differed in the thickness of their adhesive layers. To comprehensively assess the dynamic characteristics of the specimens, two experimental approaches were employed: the inertance function in the small-strain domain, and the sweep load response for large strains.

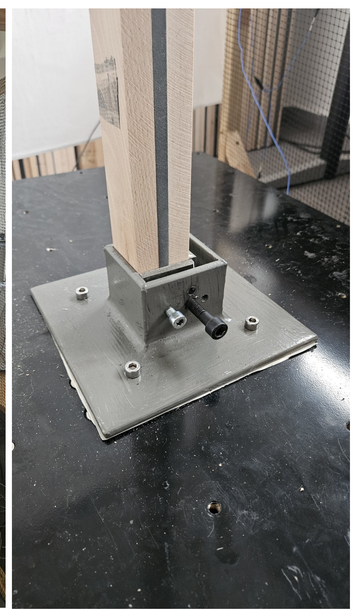
METHODS

LABORATORY SETUP



$L_1 + L_S = 1560$ mm
$M = 5.93$ kg
$h = 50$ mm, $b = 50$ mm

Hight of wooden Lamella [mm]	Thickness of the agesive layer [mm]
24	2
20	10
17.5	15
15	20



All specimens were fixed to the shake table QuakeLogic Bi-Axial-TDG Shake Table. Two accelerometers PCB Piezotronics model 356A16 were attached to each specimen – one in the middle and the other at the top of the specimen. Impact tests were carried out with the use of 086D20 type impact hammer

EXCITATION OF VIBRATIONS

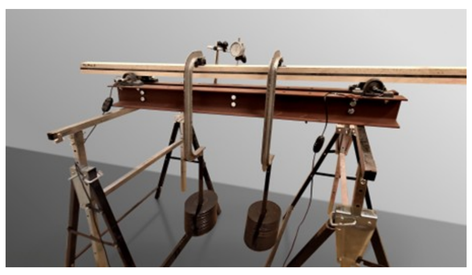
Three types of load were employed:

- Impact hammer hitting the top of the cantilever
- Manual deflecting of the cantilever top.
- Sweep tests were conducted in three frequency ranges:
  - 2–6 Hz (beams with attached mass)
  - 10–17 Hz (adhesive layers 2 mm and 10 mm)
  - 8–12 Hz (layers 15 mm and 20 mm).

STAGES OF THE STUDY

- Vibration excitation to detect natural and resonance frequencies
- Long-term excitation with detected frequency
- Re-excitation to check frequency and damping change

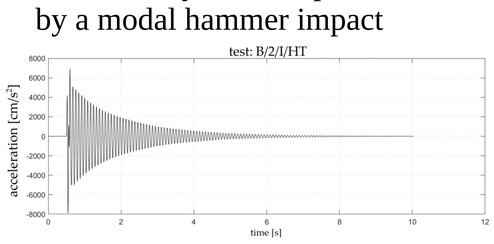
Static four-point bending test to investigate flexural stiffness



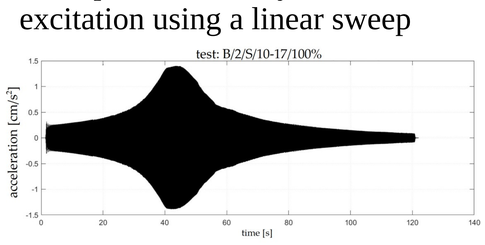
bondline thickness t [mm]	midspan deflection u [mm]	flexural stiffness EI [Nm2]
0 (solid beam)	1.37	5337.29
2	2.7	2708.18
10	2.48	2948.42
15	1.92	3808.38
20	1.56	4687.23

Additional mass to increase stresses and bring the frequency closer to seismic and wind loading

Time history of a sample excitation by a modal hammer impact

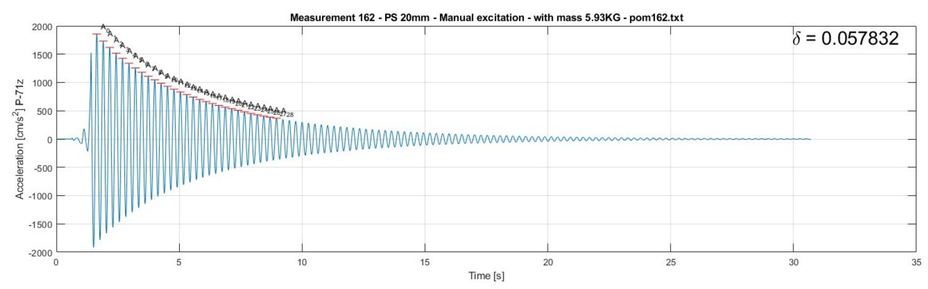


Example time history of shake table excitation using a linear sweep

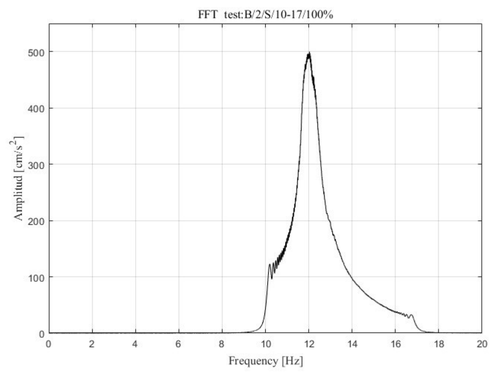


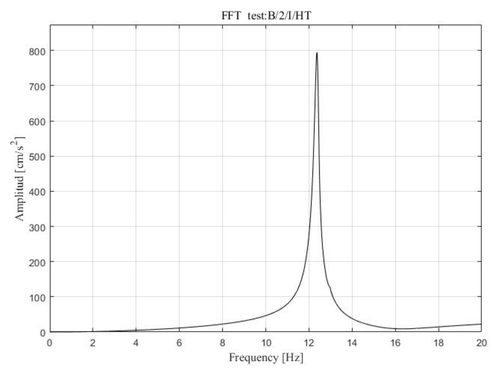
RESULTS

Damping properties of the composite beams were estimated by logarithmic damping decrement

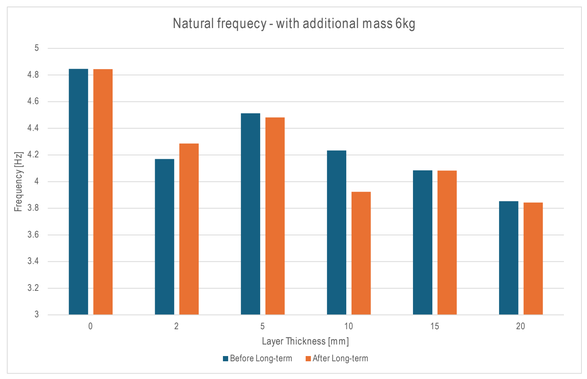


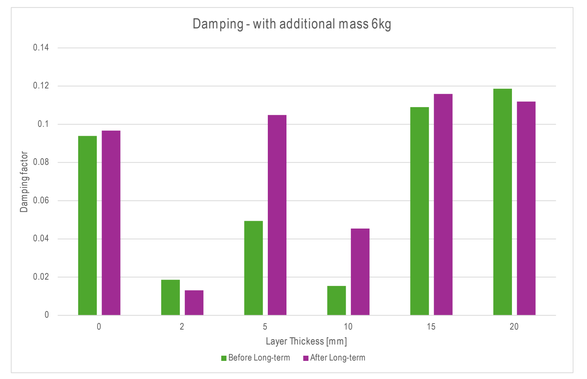
Resonance frequencies in both sweep and impact tests were determined as the peak values of the FFT spectrum of the accelerograms.



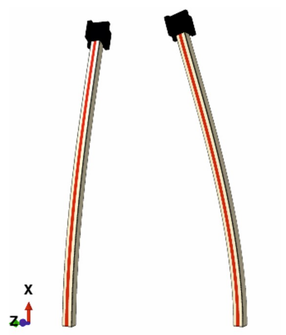


Natural frequency and damping changes during long-term excitation - dependence on the thickness of the polymer layer

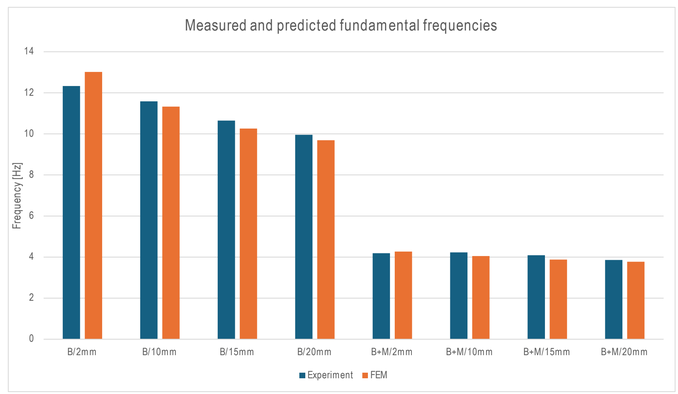




Fundamental eigenfrequencies and vibration modes in two perpendicular directions Y and Z.



Agreement between the experiment and the numerical prediction



CONCLUSIONS

- Sweep tests indicated clearly that the response of the adhesively bonded beam is nonlinear – resonance frequencies were observed to drop as the amplitude of excitation increased.
- FEA simulations match the experimental results very well. For very thin adhesive layer, numerical predictions are somewhat overestimated, while in cases of greater adhesive thickness, numerical simulations provide slightly underestimated natural frequencies. However, the differences do not exceed 5%.
- Further research will be focused on analyzing other types of flexible polyurethane adhesives, on the influence of deformation history (cyclic loads) on mechanical properties of adhesives as well as on global response of composite beams.
- The problem of nonlinearity of dynamic response in case of large deformations should also be the subject of an in-depth investigation.

REFERENCES

Jarosław Chełmecki , Paweł Szeptyński , Dorota Jasińska , Arkadiusz Kwiecień

„Analysis of vibration response of adhesively bonded composite cantilevers”, Materials [2025]