

One of a series of short briefings on timber technology produced by the towards Adhesive-Free Timber Buildings (AFTB) research project. The project is co-funded by Interreg NWE, 2016-2020. This note explains the behaviour of the Adhesive Free (AF) EWPs (beams and panels) are subjected to vibrational forces.

The study of the behaviour of Engineered Wood Products (EWPs) includes the investigation of the serviceability limit state with regard to the vibrational comfort of those structural products. This is done by following the European standards described in the Eurocode 5.

Eurocode 5 main design requirements

- **Fundamental first frequency** $f_1 = \frac{\pi}{2L^2} \sqrt{\frac{(EI)_L}{m}} > 8 \text{ Hz}$

The value of 8Hz has been suggested by the Eurocode 5 as being the lower limit natural frequency that floors can have to avoid poor vibrational comfort due to footsteps.

The first frequency of a given structural element (beam or panel) is mainly depending on its span $[m]$, the bending stiffness $(EI)_L [Nm^2/m]$ and the mass $m [kg]$.

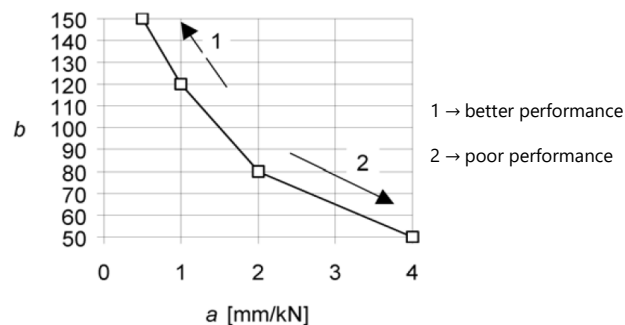
- **Deflection under unit load** $w \leq a \text{ (mm/kN)}$

The displacement caused by a static unit point load should be limited by a parameter $a [mm/kN]$, to ensure that the bending stiffness is appropriate and acceptable.

- **Velocity under a unit impulse** $v \leq b^{f_1 \zeta - 1} \text{ (m/Ns}^2\text{)}$

This dynamic criterion limits the magnitude of the transient response due to the heel impact of a footstep that generates higher frequency components. It is translated to the limitation of the vertical floor vibration velocity $v [m/s]$ to a combination between a parameter b , the fundamental frequency $f_1 [Hz]$ and its modal damping ratio $\epsilon \zeta$.

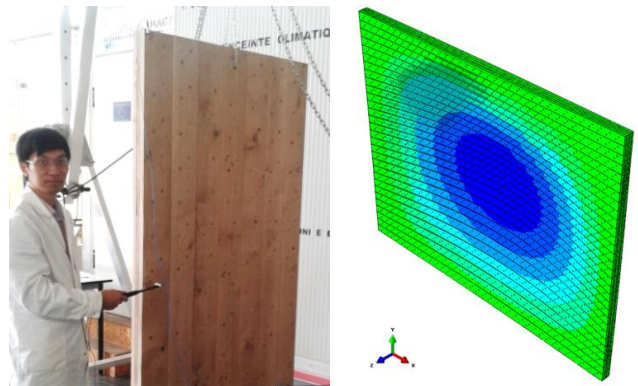
The parameters a and b are presented in the figure below with recommended range of limiting values and the recommended relationship between the parameters.



According to Eurocode 5, these three requirements should be satisfied in order to verify the serviceability limit state of vibration.

Serviceability limit state of AF EWPs

The University of Lorraine used the results of experimental tests on vibrational comfort of middle-scale AF CLT panels in order to validate the developed numerical model, which in turn was used to predict the vibrational characteristics of full-scale AF CLT floors.



Serviceability limit state of AF EWPs

- **Adhesive Free Timber panels**

The numerical model was used to simulate the vibration behaviour of a full-scale dowelled CLT panel.

*Dimension of the panel : 4,5 m x 5,5 m x 0,175 m (5 plies)
 Wood species : Spruce (Picea) and Oak (Quercus robur)*

	Spruce floor	Oak floor	Eurocode 5 requirements
1 st frequency f_1	13,1 Hz	11 Hz	> 8 Hz
Unit deflection (a)	0,92	0,82	0,5 – 4 mm/kN
Parameter (b)	131	137	50 – 150
Unit impulse velocity v	0,009	0,006	$\leq 0,012 \text{ m/Ns}^2$

- **Adhesive Free Timber beams**

The three first frequencies of both glued and dowelled three-layer oak beams have been assessed experimentally and compared.

*Dimension of the beam : 1,45 m x 0,07 m x 0,0675 m (3 layers)
 Wood species : Oak (Quercus robur)*

	Glued beam	Adhesive free beam
1 st frequency f_1	140,0 Hz	137,7 Hz
2 nd frequency f_2	363,3 Hz	332,5 Hz
3 rd frequency f_3	677,0 Hz	588,3 Hz

- **Conclusion**

Based on the comparison between frequencies of glued and dowelled beams, it seems that the frequencies exhibited by the dowelled beams are acceptable. Moreover, based on the numerical simulation results, the adhesive free CLT panel complies well with the Eurocode 5 design requirements with regard to the serviceability vibrational comfort.

Stakeholders welcome

A key aim of the project is to engage with businesses, regulators and other interested parties. Adhesive-free timber building technology could be of interest to your business.

Please get in touch via the e-mail addresses below:

For more information please visit the Adhesive Free Timber Buildings (AFTB) project website <http://www.nweurope.eu/AFTB> or use the contacts.



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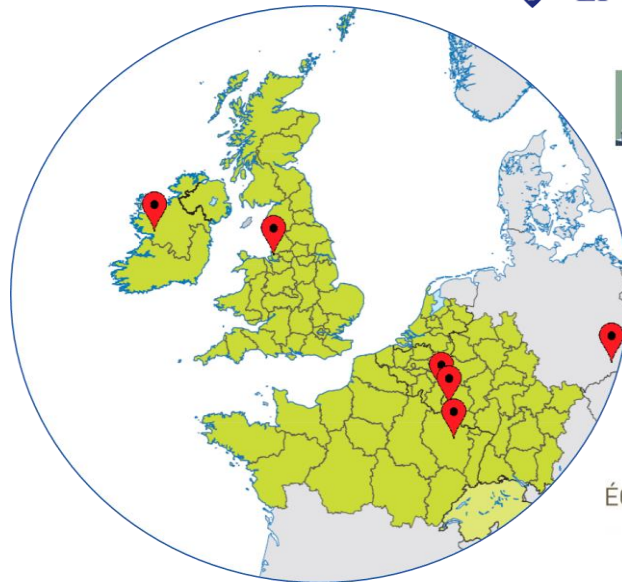
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