# Keynote lecture: Utilizing Experiments and Numerical Models as basis for Structural Engineering

**K.A. Malo**[†*]

[†*]NTNU Norwegian University of Science and Technology, kjell.malo@ntnu.no

Building with wood has gained much attention in the last decades mostly due to its favorable footprint with respect to the global heating problem. Wood has found its way into engineered components like glue-laminated beams, cross-laminated plates and veneer-laminated sheets and plates; with rapidly increasing popularity in the building industry. Moreover, these quite complex components also serve as parts in even more complex components like deck-, roof- and façade elements, most likely in composition with other materials.

Complex multiscale numerical models exists, capable to model also wood from maybe the molecular or micro level and all the way up to the up to scale of buildings structures. However, these models are currently not very applicable to the structural engineer due to missing documentation of a vast number of parameters as well as insufficient computational resources available. Another fact is that the structural engineer has no control of the wooden material actually to be used in a building structure; it might even not be harvested at the stage of the design of a building. The structural engineer is left with wooden materials, which have been characterized in certain classes with characteristic properties and statistical distributions. These characterizations, important for strength and stiffness, are based on certain measureable quantities like wave speed, density, deformation under trial load, or some optical methods.

Although wooden materials are classified and class properties are stated, these parameter sets are far from enough for more detailed numerical models of structural behavior e.g. in a connection between two wooden elements. The lack of proper numerical models for structural behavior of both components and connections in wooden structures, hampers the development of improved structural design. In the present keynote lecture, some of the recent research projects at NTNU addressing these topics are discussed.

The role of experiments has been, and is still important for wooden structures. Traditionally, series of experiments were performed to explore the effect of some parameters on strength or deformation, giving enough data to curve-fit the results to some simplified analytical expression, useful for engineering design. However, nowadays the role of experiments are more directed towards calibration or validation of a numerical modelling approach. The latter approach is much more generic in nature, and is more powerful, e.g. in order to develop improved structural detailing.

Basically, all structural FEM models must have data representing the materials, geometry, and internal and external boundary conditions, in order to compute the response to some modelled exposure. The geometry of a continuum is effectively represented by the finite element method. Boundary conditions must be paid sufficient attention as these seldom can be modelled by the basic degrees of freedom in the FEM models. Compared to other material, modelling of wooden material are challenging due to its complexity in any scale and the large variability due to uncertain growth conditions as well as the history of treatment after the harvesting. The natural growth of trees develop branches and results in knots and flaws, together with grain variations. Moreover, the physical behavior is dependent on temperature and moisture content, and the response shows also time dependency. Furthermore, the interaction of wood with other materials like steel needs special attention as too simplified approaches do not give accurate results.

The following topics, relevant for softwood, are addressed in the keynote lecture:

Material modelling of clear wood in meso/macro/component scale by anisotropic models. Effects of varying moisture content and resulting internal stresses. Effects of long term loading in interaction with varying moisture.

Contact properties between wooden parts and wood to metal parts. Threaded rods and screws behavior and modelling.

Localized stresses and fracture development, experiments and models.

Numerical modelling and updating of parameters.

Modelling and development of structural systems.

ISBN: 978-91-88898-64-7