# Finite Element Design and Manufacturing of a Nylon-String Guitar Soundboard from Sandwich-Structured Composites

*Negin Abaeian,*[1†] *Ulrich Blass,*[2] *Gary Scavone*[1] *Larry Lessard*[2]

[1]Computational Acoustic Modeling Laboratory, Schulich School of Music, McGill University
[2]Structures and Composite Materials Laboratory, Dept. of Mech. Engineering, McGill University
[†]negin.abaeian@mail.mcgill.ca

**ABSTRACT**

Composite materials have many potential advantages over wood in the construction of string instruments, including less sensitivity to humidity and temperature, better durability, as well as uniformity of mechanical properties that can lead to more predictable vibrational behaviour. While composite instruments have been commercially available for several decades, the acoustic properties of these alternative materials are still relatively unknown to many luthiers. The aim of this project is to use Finite Element Methods (FEM) to design and manufacture the soundboard of a nylon-string guitar from sandwich-structured composites, and compare its vibrational behaviour with that of a reference wooden one. In order to minimize the effects of other factors in this replacement, the soundboard is treated independently from the rest of the body, and the pattern of the braces behind the soundboard remains unchanged. First, following an experimental modal analysis on the reference wooden soundboard, the wooden soundboard is modelled in Abaqus, where the properties of the model are adjusted to match the real soundboard. The design process then starts by designing the composite top plate to have the same bending stiffness and density as the reference wooden top plate. The two top plates are then simulated using FEM under free boundary conditions, where the thickness and material properties of the core and the composite layers are varied so that the designed top plate matches the simulated wooden one in mode-frequencies of up to 1000 Hz and in the first few mode-shapes. The same procedure is followed after adding the braces to both models, until the mode-frequencies and the mode-shapes of the simulated composite soundboard are reasonably similar to those of the simulated wooden soundboard. Finally, to choose between the most promising designs, the composite soundboard designs are compared with the simulated wooden soundboard under hinged-boundary conditions, i.e. fixed-translation and free-rotation. The designed soundboard is then manufactured, followed by an experimental modal analysis on the composite soundboard, from which the mode-shapes, mode-frequencies and the damping values are estimated and compared with those of the wooden soundboard.