應用 CAE 與 EMA 於小提琴面板素材之機械性質測定

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摘要

面板是小提琴的重要組件之一,取得木材的機械性質是進行小提琴振動與聲學模擬分析必要的參數。本文針對兩種面板木材求得其材料參數,利用 CAE 有限元素分析軟體可得到結構模態參數,也以傳統實驗模態分析方法,使用衝擊錘及加速規量測結構頻率響應函數,並取得素材平板的模態參數,包括:自然頻率、模態振型及模態阻尼比。本文探討一塊完整桃花心木單板,以及一塊拼板的台灣欅木平板。透過模型驗證,在比對分析與實驗量測得到的模態參數,可以驗證木材的材料參數,得到木材平板的等效有限元素分析模型。結果顯示,木材以正向性材料模型可達到模型驗證的目標,完整桃花心木板及拼接台灣欅木木板都可藉由同樣手法測定出小提琴面板素材正向性材料模型參數,發現此兩種類型樹種之機械性質差異甚大。本文建立的實驗與模擬方式,可以適當地取得木材素料的材料模型參數,未來可與加工後之小提琴面板進行比較差異,並求得如小提琴背板及側板之材料機械性質,以能夠建構整支小提琴分析的材料模型。

關鍵字:機械性質、小提琴面板、桃花心木、台灣欅木

Application of CAE and EMA to Determination of Mechanical Properties for Violin Top Plate Materials

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Abstract

Violin's top plate is one of key components in making violins. To obtain mechanical properties of wooden materials is required so as to carry out numerical simulation of violin's vibration and acoustical effects. This work aims to obtain material parameters for two kinds of wooden plates. We adopt computer aided engineering (CAE) software by finite

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element analysis (FEA) to examine the wooden plate's modal parameters. Experimental modal analysis (EMA), the experimental approach, is also performed by using the impact hammer and accelerometer to measure frequency response functions (FRFs) and to determine the plate's modal parameters, including natural frequencies, mode shapes and modal damping ratios. Two wooden plates are investigated. One is a rectangle plate made of mahogany. The other plate is about the size made of Taiwan red beech but bonded with two pieces of plates. Through the model verification process by comparing those modal parameters obtained from CAE and EMA, respectively, the equivalent FE model can be validated to get the correct material parameters. Results show the orthotropic material model is adequate to simulate the wooden plates. The mechanical properties are quite different between mahogany and red beech. The experimental and numerical approach can properly identify wooden plate's mechanical properties. The methodology can also apply to other wooden materials for back plates and necks as well as the manufacture violin components so as to build up the material models for the violin.

Keywords：Mechanical Property, Violin Top Plate, Mahogany, Taiwan Beech