

Response to GAL Question

"I have a picky customer that regularly brings back the classical guitar I built some years ago for action adjustments. The fingerboard is ebony and the neck is mahogany. The action does change – sometimes it is higher and sometimes lower, but the guitar is always playable. We have dealt with this so far by string tension changes. Does anyone have any ideas about structural changes to the instrument that would minimize these changes? I like this guy, but I'd rather see him a little less often."

There is no simple structural change, that you can make to the instrument now, that will alleviate this problem. However, it is worth understanding what is likely causing the problem so that you can consider whether or not you want to make the required changes to this instrument or incorporate these concepts into future instruments.

The most likely cause of the problem is differential expansion/contraction with atmospheric humidity change. Any two materials (e.g. timbers) with different coefficients of longitudinal dimension change per % change in moisture content, if bonded together (as for example a fretboard and a neck shaft) will exert a force so as to bend the structure (guitar neck) when the wood's moisture content varies from the moisture content at which the two materials were glued together. The wood's moisture content will, of course, follow the prevailing level of ambient relative humidity. As humidity rises, the fretboard gets relatively longer as the ebony expands more and forces the neck into a back bow. The opposite happens when the humidity drops. For years, luthiers have made hygrometers utilising this principle. The response is similar to the response of a bi-metal strip reacting to temperature change. How much the structure bends (in this case the guitar neck) is dependant on three main factors and a couple* of less significant ones - the differential in the coefficient of longitudinal dimension change, the magnitude of the change in moisture content, and the stiffness of the whole neck as a structure (a stiffer structure will resist the bending forces more and so deflect less under the loads caused by the change in moisture content). As it turns out, ebony is one of the most unstable woods with quite significant changes in both cross and long grain dimensions as humidity changes, whilst mahogany, on the whole, is one of the most stable, so the combination has one of the largest differentials and is therefore one of the most problematic in terms of bowing as the seasons change. So a first consideration is of material choices. For example, generalising broadly, the rosewoods "move" only about half as much as the ebonies. If you must use ebony, Macassar ebony typically moves the least of the ebonies. Strange as it may sound, you should also consider using a less stable neck shaft timber to further reduce the differential between the neck timber and the fretboard timber. A second consideration is to better control the environment in which the guitar is kept, essentially trying to keep the guitar at a constant humidity. There are well known ways of achieving this that may be more or less applicable to the present situation. Finally, the neck can be made stiffer. One way of achieving this is by adding carbon fibre rods to the neck shaft. However, using the types of rods that are typically available and placing them in the neck wood beneath the fretboard achieves a stiffness increase of ~9%. A similar increase in stiffness can be achieved by making the neck ~1mm thicker.

A more versatile solution is to do what the steel string fraternity has done for decades: install an adjustable truss rod. Steel string guitars are generally set up with a much lower action, so any change in neck bow is much more noticeable and with an adjustable truss rod the change can be nullified. Progressively more classical guitar makers are adopting this very sensible approach. Arguments against such as "upsetting the balance of the instrument" due to the extra mass of the truss rod are mostly spurious. Just use less ebony (or none at all) in the fretboard.

For those that don't like metal in the neck (what about your tuners?) there is the old school method of "balancing the sandwich", by having similar materials on both "faces" of the neck. The practical manifestation of this is more ebony(!), a full depth ebony lamination down the middle of the neck, typically around 10mm wide. This places at least some "unstable" material on the underside of the neck to balance the reaction of the fretboard, whilst also making the structure stiffer (ebony is typically about twice as stiff as mahogany) and this may be enough together to reduce the problem to negligible proportions.

* The less significant factors are the Young's modulus of the materials and the relative thicknesses of the materials. For example in these circumstances, a thin ebony fretboard will likely be less problematic than a thick fretboard and a less longitudinally stiff fretboard (lower long grain Young's modulus) will also alleviate the problem as the forces exerted will be smaller. As long grain Young's modulus can vary by a factor of two within species and different builders use different fretboard thickness (as well as there being within species variations in the coefficient of longitudinal dimensional change with humidity) it rapidly becomes apparent why this problem is not always manifest.

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