Dyson Bursary Project - Summary

CAN BAMBOO REPLACE WILLOW IN CRICKET BATS?

Ben Tinkler-Davies

This project worked on material testing of bamboo to determine whether or not it could replace willow for use in cricket bats. Alongside this some finite element modelling (FEM) was used to model the impact between the cricket bat and ball.

The material used for the blade of a cricket bat should be as stiff as possible, with a handle with a lower stiffness. This will allow the highest energy transfer from the player's hands to the bat. At the same time the material should be lightweight, so that the player can control its movement easily. However, there is the trade-off between weight and strength as a thinner bat will be easier to control but transfer less energy to the ball and be more likely to break. Historically Salix Alba, a light coloured willow, has been used for cricket bats as it is lightweight with high stiffness and surface hardness. In this project laminated Moso Bamboo (Phyllostachys edulis) was compared with the willow currently used for bat manufacture to determine whether it has the correct properties for use as a cricket bat.

(a) Bamboo (b) Willow

Figure 1: Cross section images of the bamboo and willow.

Many experiments were carried out over the course of this investigation and they are summarised in *Table 1*. In this case the Modulus of Elasticity (MoE) is a measure of the stiffness of a material so we can see that bamboo is much stiffer than willow in both tension and compression. As well as this it has similar vibration properties. This is important as a bat that has lots of vibrations and not a lot of damping will be uncomfortable to hold will not be a very good bat. Since bamboo and willow have similar fundamental frequencies and damping ratios we can say that the bamboo bat may be as good as willow.

Material property	Units	Laminated bamboo	Willow	Difference/%
Specific tensile strength	kPa m^3/kg	86.8±46.1	258.3	33.6
MoE under tension	GPa	22.7±6.0	16.9	134.3
Specific compressive strength	kPa m^3/kg	31.7±10.0	48.5	65.4
MoE under compression	GPa	8.5±3.6	6.6	128.8
Bending stiffness	GPa	16.6±5.0	3.5±1.6	474.3
Deflection under bending load	mm	7.9±3.1	18.0±5.4	43.9
Density	kg/m^3	710±63	400-600	∼142
Fundamental frequency	Hz	606.5±64.5	400-700	∼110.3
Damping ratio		0.21±0.28	0.22	95.5
Max surface hardness	HV	17.0±3.0	9.3±1.7	182.0
Average CoR over a range of velocities		0.47	0.40	117.5
Fracture toughness	MPa $m^{\frac{1}{2}}$	8.0	2.3	347.8

Table 1: Summary of results obtained for direct comparison of material properties between laminated bamboo and willow.

Finally, some FEM was carried out to try and understand how a cricket ball would bounce off the surface of a bat. The Coefficent of Restitution (CoR) is a measure of how much energy is lost during an impact so we can use this to try and characterise the bamboo bat under testing. As we can see in *Figure 2* there is a spot in the middle of the bat with a high CoR, this is called the sweet-spot. From the testing we can see that there is a section in the middle which has very good performance but towards the edges the performance of the bat decreases. This is to be expected as the bat is thinner on the extremities and thickest in the centre of the bat.

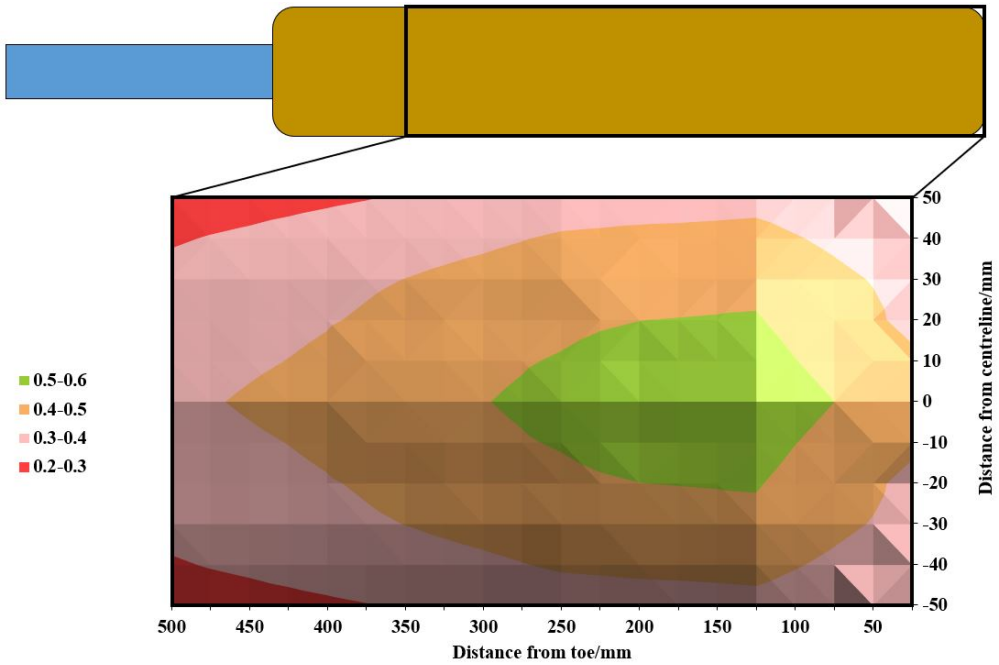

Figure 2: Coefficient of Restitution surface for a bamboo blade impacted by a cricket ball at 50mph, showing the sweet spot in green.

We were lucky enough to be able to work with a cricket bat manufacturer who produced 2 bats for us, as seen in *Figure 3* and *Figure 4*. Since bamboo is considerably denser than willow the bats were much heavier than the willow ones currently used. However, when the ball was hit with the bat it did travel a long way and at speed. This indicated that with further work on the shaping of the bat it could make a good replacement for willow in cricket bats.

Figure 3: Face of prototype bamboo cricket bat and blade produced by Garrard & Flack.

Figure 4: Rear of prototype bamboo cricket bat and blade produced by Garrard & Flack.

In the future work will be completed on optimising the shape of the bats so that they are not too heavy for players to use whilst still being able to hit the ball far. Because of all of the material testing that I did throughout this project it was very interesting and threw up some new findings, as laminated bamboo is still a relatively new material. I am hoping to continue working with my supervisor and other bat manufacturers to be able to finish off this project and, hopefully, create a cricket bat that can be used in matches and training around the world.