Development of grading methods for round bamboo

Suneina Jangra
Coventry University

OVERVIEW

Bamboo is cheap, renewable, and has a high strength-to-weight ratio making it an excellent structural material. It is widely used in the construction of houses around the world, and increasingly, for more complex structures such as foot-bridges and schools.

©PT Bambu: 'Green School' Bali, Indonesia

Most bamboo construction is based on experience instead of structural design to codes and there is at present very little formal guidance for designers. The most useful codes are Colombia's NSR-10, ISO 22156 and the National Building Code of India however these do not provide a comprehensive design procedure.

As a natural, organic material, the physical properties of bamboo are extremely variable and it is therefore difficult to predict the structural capacity of individual 'culms'. The exact strength of a specimen can only be determined through destructive testing however, by establishing relationships between the actual strength and properties which can be measured non-destructively, it is possible to estimate the strength of a culm.

RESEARCH AIMS

1. To correlate one or more easily measureable physical or mechanical property through simple, rapid, non-destructive tests to one or more flexural strength properties of a particular bamboo species.
2. To establish key indicating properties from which flexural properties can be estimated.
3. To propose a classification system for dry round bamboo based on the relationships established between indicating properties and flexural properties.
4. To investigate the reliability, simplicity, cost and speed of the proposed grading and classification method.

METHOD

286 samples of *Guadua angustifolia* bamboo were sourced from Colombia and each specimen was subjected to several tests to measure specific material and strength properties.

Using a Brookhuis Timber Grader MTG ®, the Dynamic Modulus of Elasticity of each culm is determined based on stress-wave velocity, given by the following equations:

$$Dynamic\ MOE = v^2\rho$$

$$v = 2FL$$

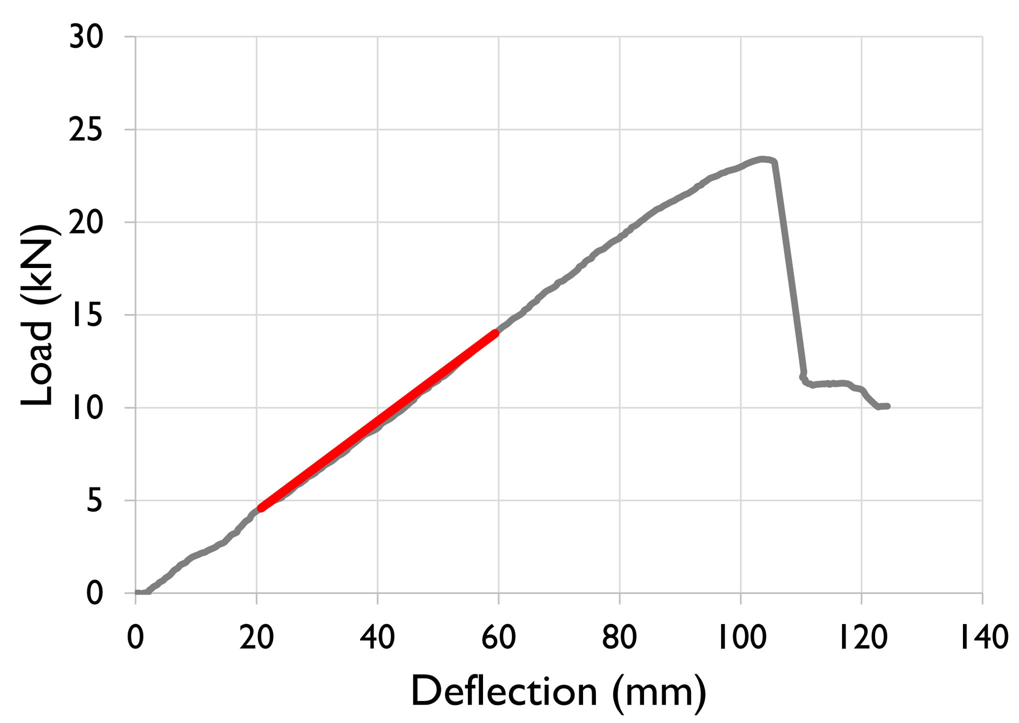
$v = stress\ wave\ velocity$
$\rho = density\ of\ specimen$
$F = frequency\ of\ stress\ wave$
$L = length\ of\ specimen$

Brookhuis Timber Grader MTG ®

A four-point bending test was then conducted to determine the Static Modulus of Elasticity, the Modulus of Rupture (strength) and the bending moment capacity of each specimen. The test configuration is shown to the left.

Specimens were loaded at a rate of 0.5m/s and deflection was measured at the mid-point and supports.

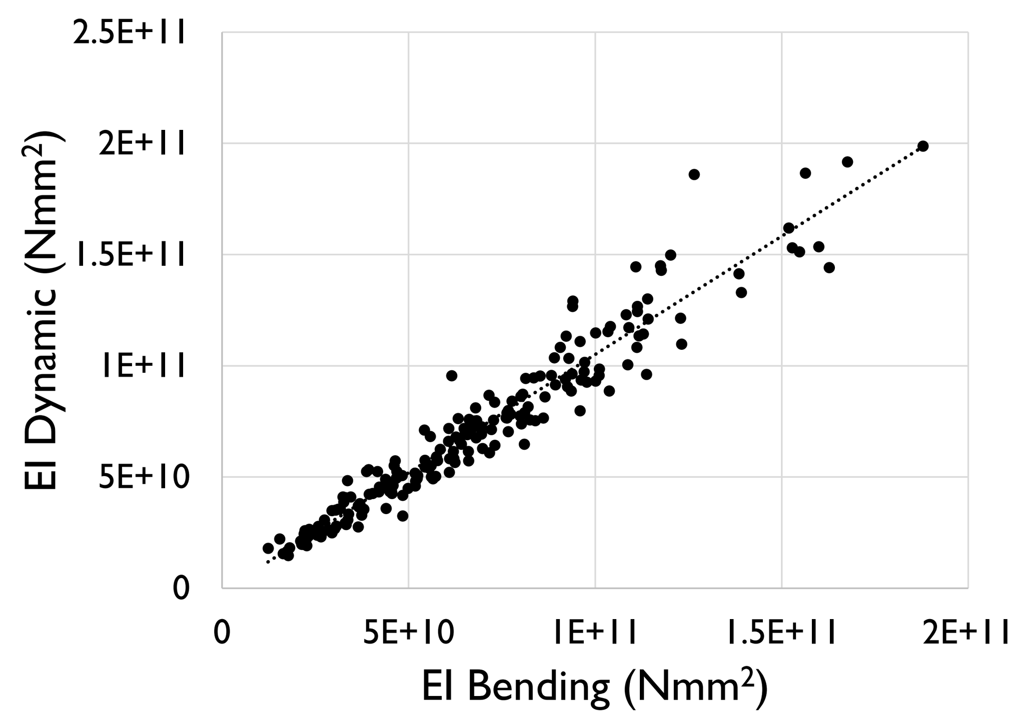
The experimental Static Modulus of Elasticity of the specimen is shown in red on the resulting load vs. deflection curve.



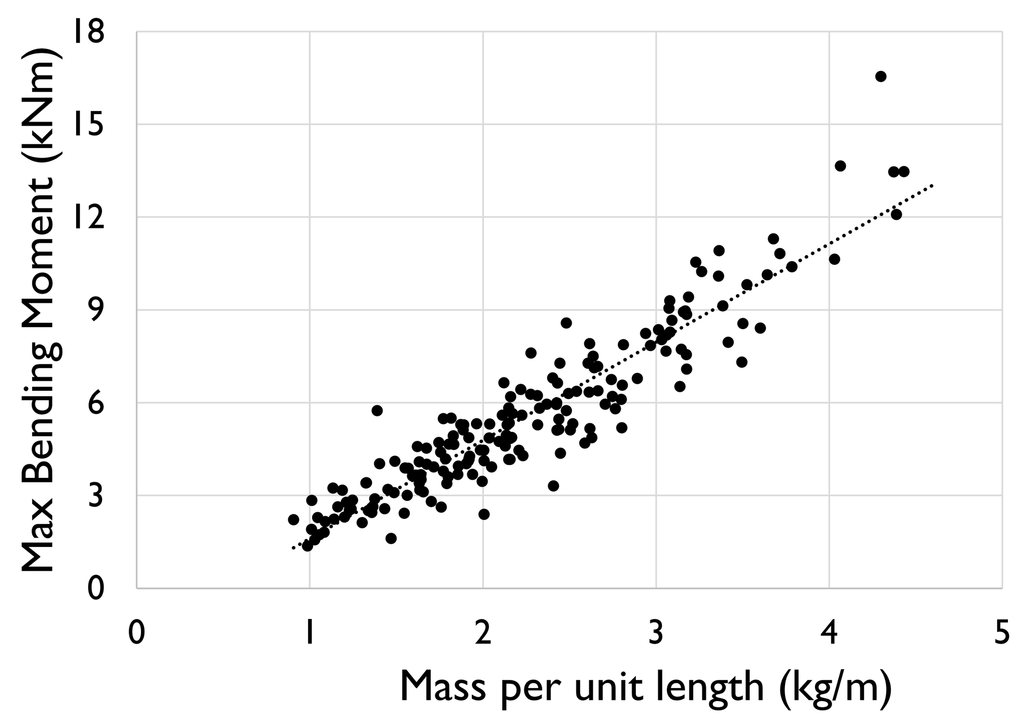
Subsequently, using a range of statistical methods the non-destructively measured properties were correlated to the stiffness and strength properties obtained from the bending test.

RESULTS & CONCLUSIONS

Tests resulted in promising correlations between the measured physical and mechanical properties and the flexural properties determined from destructive testing.



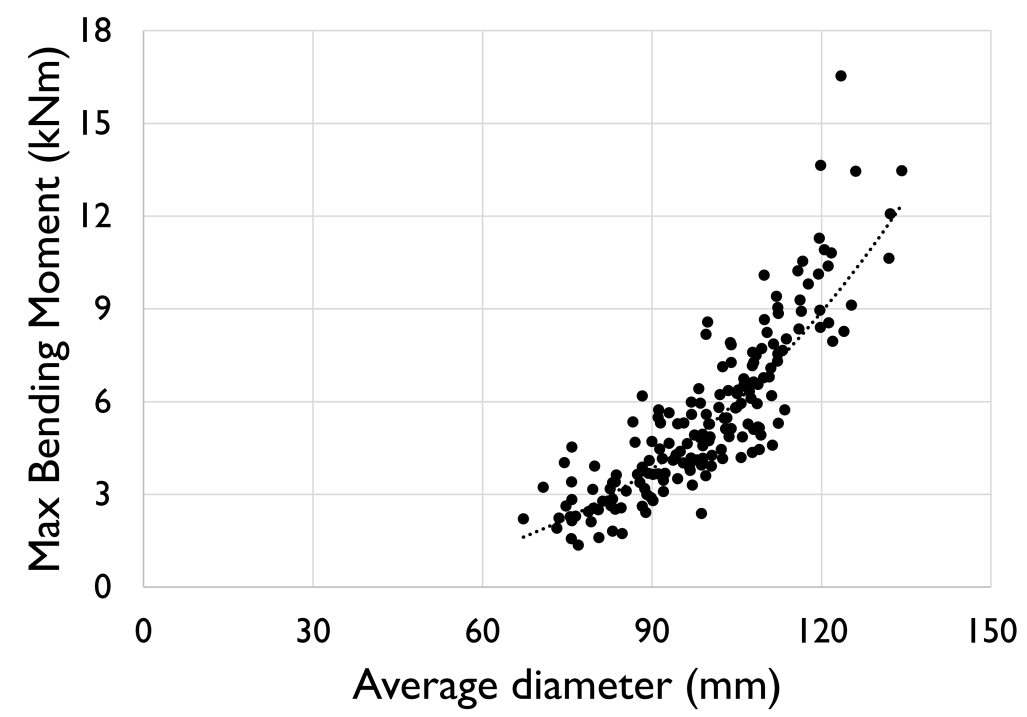
For EI Bending (flexural stiffness) against EI Dynamic, the correlation coefficient was R^2=0.932 and for EI Bending vs Max Bending Moment (flexural capacity), the correlation was found to be R^2=0.851.



In particular, mass per unit length and average external diameter were found to be good indicators of strength with high R^2 values as shown in the tables below.

Mass per unit length:

	R^2
Max Bending Moment	0.866
EI Bending	0.865



Average diameter:

	R^2
Max Bending Moment	0.752
EI Bending	0.869

Mass per unit length and average external diameter were selected as strong indicating properties for flexural stiffness and flexural capacity and two possible grading systems are proposed; using diameter alone, and a combined method using both diameter and mass per unit length.

jangras@coventry.ac.uk

Supervisor: David Trujillo