



**Juan Simón Obando Zapata**

**Characterization of Bamboo along its Culm for  
the Production of Bamboo Laminated Beams**

**Dissertação de Mestrado**

Dissertation presented to the Programa de Pós-Graduação em Engenharia Civil of the Departamento de Engenharia Civil, PUC-Rio as partial fulfillment of the requirements for the degree of Mestre em Engenharia Civil.

Advisor: Khosrow Ghavami

Rio de Janeiro  
April 2015



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### Ficha Catalográfica

Obando, Juan Simón Zapata

Characterization of bamboo along its culm for the production of bamboo laminated beams / Juan Simón Obando Zapata; Adviser: Dr. Khosrow Ghavami; – Rio de Janeiro: PUC, Departamento de Engenharia Civil, 2015.

84 f. il (color) ; 30 cm

Dissertação (mestrado) – Pontifícia Universidade Católica do Rio de Janeiro, Departamento de Engenharia Civil, 2015.

Inclui referências bibliográficas.

1. Engenharia Civil – Teses. 2. Bamboo. 3. Laminate Glued Bamboo LGB. 4. Bamboo-Laminated Beam. 5. Bamboo structural characterization. 6. Non-Conventional Materials. I Ghavami, Khosrow. II Pontifícia Universidade Católica do Rio de Janeiro. Departamento de Engenharia Civil. III Título.

CDD: 624

To mom and dad:  
The masterly architects and thorough promoters  
of my wonderful immense human adventure

## Acknowledgments

Several months have been spent for the preparation of this dissertation, with the contributions of many people by giving me the support and the encouragement I needed. For this reason, I would like to acknowledge a few who have helped me with this research.

First, I want to thank my professor, advisor and companion Khosrow Ghavami, for his guidance, support and advises throughout this study. I thank very much the PhD student João Krause for his willingness and collaboration since the beginning of this work and professor Jose Jaime Garcia for his precise comments. I want to thank Juan Ossa for his invaluable work, especially with corrections and editing of the dissertation.

My thanks are also to PUC-Rio staff for their hospitality and to CAPES for financial supports during my staying time in Brazil. I would like to give special thanks to lab technicians Victor, Adrian and Anderson from ITUC, Jose and Euclides from Civil Engineering laboratory and Messias from architecture workshop for their time and diligence in the development of this work.

I also want to thank to my brothers, Cesar and Daniel for their unconditional friendship, to Rhaissa for her constant support and motivation and to Erika for always making me feel at home.

Finally, I want to thank my beloved mom, the strongest being in the world, my dad the greatest partner, my family “the big treasure” especially the couple of inspiring Antonias, for always encouraging to dream and supporting me throughout.

## Abstract

Zapata, Juan Simon Obando; Ghavami, Khosrow (Advisor); **Characterization of bamboo along its culm for the production of bamboo laminated beams**. Rio de Janeiro, 2015. 84 p. MSc. Dissertation. Departamento de Engenharia Civil, Pontifícia Universidade Católica do Rio de Janeiro.

Laminated bamboo was created to standardize the raw material in order to increase its strength, control its shape and develop sustainable and innovative structural elements. Bamboo is a Functionally Graded Material (FGM) due to the progressive distribution of the fibers across its wall thickness. This research presents the results of an experimental investigation series in which bamboo culm, of *Dendrocalamus giganteus*, was divided into 6 segments of analysis. Three divisions along its length, bottom, middle and top, and then two divisions across its wall thickness, inner and outer. In the first series, the specimens of each segment were tested separately to establish their tensile modulus of elasticity  $E_t$ . Six types of bamboo uniaxial-laminated beam specimens of 2.5 cm width, 5cm height and 50 cm length were assembled with layers from each particular segment of bamboo culm, using resin of mamona adhesive. Four point bending tests were conducted on beam specimens to establish the bending modulus of elasticity  $E_b$ . Experimental values of both specimen groups were compared to those of theoretical values, applying solid mechanics theory. The results provide information to improve the segment arrangement of bamboo-laminated beams upon subjection to bending loads. Based on the results, it is also possible to introduce equivalent values for the analysis of the mechanical properties of the beams, using solid mechanics theory.

## Keywords

Bamboo; Laminate Glue Bamboo (LGB); Laminated beam; Bamboo characterization; Non-conventional materials.

## Resumo

Zapata, Juan Simon Obando; Ghavami, Khosrow. (Orientador). **Caracterização do bambu ao longo do colmo para a produção de vigas de bambu laminado**. Rio de Janeiro, 2015. 84 p. MSc. Dissertação de Mestrado. Departamento de Engenharia Civil, Pontifícia Universidade Católica do Rio de Janeiro.

As lâminas de bambu foram criadas para padronização da matéria prima de modo a aumentar sua resistência, controlar sua forma e desenvolver elementos estruturais sustentáveis e inovadores. O bambu é um material gradualmente funcional (FGM) devido a sua progressiva distribuição de fibras por toda a espessura de sua parede. Esta pesquisa apresenta os resultados de uma série de investigações experimentais em que o colmo de bambu (*Dendrocalamus giganteus*) foi dividido em 6 segmentos de análise. Três divisões ao longo do seu comprimento, em sua porção baixa, média e alta, e, em seguida, duas divisões de sua espessura, interior e exterior. Na primeira série, os espécimes de cada segmento foram testados separadamente para estabelecer o seu módulo de elasticidade à tração Et. Seis tipos de vigas de bambu uniaxial-laminadas, de 2,5 cm de largura, altura 5 centímetros e 50 cm de comprimento, foram montadas com camadas de cada segmento específico do colmo do bambu, utilizando resina adesiva de mamona. Quatro ensaios de flexão pontual foram realizados em amostras de viga para estabelecer o módulo de elasticidade em flexão, Eb. Os valores experimentais de ambos os grupos de amostra foram comparados com os valores teóricos, aplicando a teoria da mecânica dos sólidos. Os resultados forneceram informações para melhorar o arranjo dos segmentos das vigas de lâminas de bambu sujeitas a cargas de flexão. Baseado nos resultados, também é possível introduzir valores equivalentes para análises das propriedades mecânicas das vigas usando a teoria da mecânica de sólidos.

## Palavras chave

Bambu; *Laminate Glue Bamboo* (LGB); viga laminada; caracterização do bambu; materiais não convencionais.

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