BAMBOO: HIGH TECH ECOLOGICA MATERIAL of XXI Centaury



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Associação brasileira em materiais e tecnologias não convencionais







Future industry

 CO_2

 O_2

Modern industry

CO₂

INTERNACIONAL/CIÊNCIA

QUINTA-FEIRA, 16



EMBARCAÇÃO revestida de amianto iria para a Índia para ser desmontado. Ecologistas protestaram

Crise flutuante retorna

irst works (1979)

First efforts to find an alternative material for asbestos-cement: availability of coconut fibers to be used as reinforcement of cementbased composites

Plates with different percentage of fibers in cement matrix

irst works: (1979) bamboo as concrete reinforcement

Executed by undergraduate students.

First tensile tests using steel code

Bamboo strips reinforcing concrete

COLUMN TWO IS NOT

Popular housing Development in big urbane areas like

City of Manaus, Capital of Amazon



Favelas in the town of Manaus - Amazonas



Center of Manaus, Capital of Amazonas



Amazon Forest

-Every country in the world suffers, in varying degrees, from social, economic and environmental problems.

-Countries with 60 % of the population living below poverty line



-Every country in the world suffers, in varying degrees, from social, economic and environmental problems.

-Countries with 60 % of the population living below poverty line have natural resources and 100% of them have bamboo (CIA-USA, 2011).



-In more economically impact of construction has provided the incentive for the use of alternative materials.

-The world temperature is rising \rightarrow It will rise between 1.4 C and 5.8 C over the next 100 years .

- * It is expected to cause flooding
- * Widespread drought

RJ-2011

* Crop failures in hotter climates





Environmental Impact

Claboration with Technical University of Berlin





Water

Claboration with Technical University of Berlin





- escalated flood risks
- polluted surface waters





History

Claboration with Technical University of Berlin





Concept for a careful urban renewal, quarter "108 Berlin-Kreuzberg", AG "Ökotop" 1983



ca. 100 plots of 2 m² at TU-Berlin, "Englische Straße" 6/86 – 5/92



24 plots at the Institut of Landscape Architecture and Environmental Planning, since 1984



PROCEDIMENTO PARA PRODUÇÃO DOS COMPÓSITOS



Cana de bambu

Polpa refinada de bambu





Câmara e bomba de vácuo



Compressão na moldagem de placas



Compressão na moldagem



Molde com material comprimido

FUROS NAS PAREDE S DO MOLDE

CORPO-DE-PROVA



Ensaio de compressão



Methodology: mechanical tests

Three point bending tests

- Mechanical parameters:
 - Bending strength (MOR)
 - Bending stiffness (MOE)
 - Energy absorption (EE)
 - Limit of proportionality (LOP)







Colheita e Processamento

Corte das Folhas



Corte/Fardo das Folhas



Transporte das Folhas



Desfibramento



Secagem ao Sol



Indústria



Why the use of NOCMAT in engineering

Social-economics motivations

- protection of non-renewable energy resources (with the adoption of low energy consumption materials and techniques).
- substitution of whole or part of polluting materials by environmental friendly ones;
- new design possibilities using nonconventional materials and techniques (e.g. vegetable fibers composites, bamboo as structural element);
- -use of local materials and labor;

-Naturally occurring composite material (cellulose fibres- lignin matrix).

-Cellulose fibres are aligned along the length [40].

-Over 1200 bamboo species have been identified globally [41].

- Bamboo is a hollow tube with nodes (diaphragms).
- -Bamboo's diameter, thickness, and internodal length have a macroscopically graded structure.







Systematic Study of the Bamboo Entire Culm: Mapping Its Physical and Mechanical Properties



espessura da parede do bambu

Physical Properties of Entire Bamboo



Número de internó

Variation of the inter node length throughout the culm for different bamboo species

Physical Properties of Entire Bamboo



External diameter as a function of the inter node number throughout the bamboos culm.

Physical Properties of Entire Bamboo



Número de internó

-The energy needed to produce 1 m3 per unit of stress in bamboo is 50 times lower than that needed for new steel production [9].

Ecological Performance

Material	Energy	Stiffness	Strength	Energy/ Stiffness (J/Nm)	Energy/ Strength (kJ/Nm)
	(GJ/m ³)	(Gpa)	(Mpa)		
Aluminium (Extrusions)	800	70	300	11.4	2.67
Steel (Grade 43 sections)	500	210	275	2.4	1.82
GRP (UD Glass/Polyester)	250	40	300	6.3	0.83
CFRP (UD carbon/Epoxy)	500	125	900	4.0	0.56
Wood (Finnish Birch)	3.8	16	80	0.24	0.048
Bamboo	3.8	25	120	0.15	0.032

Bamboo as concrete reinforcement





Analysis of composites

-Simple linear analysis, assuming a transformed section with a fixed neutral axis.

-The EC4 method for steel-concrete composites, assuming either full or partial shear connection, with a linear, plastic or elasto-plastic analysis [95].



- The linear EC5 method for timber-concrete composited known as the γ – method.



Analysis of composites

-An elasto-plastic model based on the γ – method proposed by Frangi and Fontana, (2003) [94].



- Punching shear strength

$$v = \frac{V}{b_v d}$$

v not exceed 0.8 $(f_{cu})^{0.5}$ or 0.5 N/mm²

Bamboo as concrete reinforcement



Prof. K. Ghavami/Acha

-Da Rosa (2002) [38], applied the recommend resin treatment in concrete columns reinforced with bamboo.



High tech
























Instrumentation using Strain gage





























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-Compression strength: 32.8 MPa Modulus of elasticity: 35.1 GPa.

-Tensile strength:177.97 Mpa. Modulus of elasticity: 16.54 GPa.

-Mode of failure: Punching shear.

-Crack pattern: underneath













Experimental		Theoretic	Experimental/Theoretica					
First	Failure	First	Ultimate	Ultimate	Ultimate			
crack	loadª.	crack	load	load	shear	Par/ Pul	Pcc/P'cr	Pul/ P'ul
load P.or	P.u.	load ^e	deflection	deflectiond	load ^e			
(kN)	(kN)	P.'er	(kN)	(kN)	Piu (kN)			
		(kN)						
59.7	145.42	35.36	74.76	98	131.12	0.41	1.69	1.11





Instrument	Service l		load	State limit of use		Ultimate load				
	(5KN/m²)			(L/500)						
	δ	σь	8b	q	σь	Sb	q	δ	σь	£Ь
	(mm)ª	(MPa)⁰	(‱)°	(kN/m²)₫	(MPa)⁰	(‱)°	(kN/m²)₫	(mm)ª	(MPa) ^o	(‰)°
LVDT 3	3.12							58.00		
S. gage 1		10.79	0.65		23.88	1.44			111.59	6.75
S. gage 2		12.15	0.73	6.34	23.88	1.44	16.11		128.84	7.79
LVDT 1	2.25							25.60		
S. gage 3		3.72	0.22		9.43	0.57			67.79	4.10
LVDT 2	1.40							17.30		
S. gage 4		1.45	0.09		2.98	0.18			33.43	2.02
LVDT 4	1.80							25.00		
S. gage 5		1.21	0.073		3.17	0.19			59.43	3.59
LVDT 5	2.25							26.74		
LVDT 6	1.12							16.04		

Theoretical and experimental analysis of full scale two-way concrete slab reinforced with bamboo trips

-The experimental failure load under cyclic loading was approximately 148.39 % and 110.91 % of the theoretically predicted values by FEM and ultimate punching shear load following BS 8110 [39] respectability.

-The implications of these findings show that FEM analysis and DELCAR have good precision in its application on treated bamboo strips for concrete reinforcement.

-Also it can be concluded that the gravel coating treatment on bamboo strips can be safely used and its role is achieve successfully.



Bamboo as concrete reinforcement ...Does it need something else?

Resin

Node



Geometry

Effect of moisture contents at room temperature and frozen conditions on the mechanical properties of Dendrocalamus giganteus (DG) bamboo justifica

Review of old bamboo tensile test







BAMBOO A FUNCTIONAL GRADIENT MATERIAL



- Vascular bundle -1 Sieve tube:10-20 µm D.
- -1Sheath of fibres: ~ 345 µm D.
- -Lines of xylem: 10-20 µm in Width.

- 4 Sieve tubes:(3) 210-230 μm (1) 60-80 μm D.
- 5 Sheaths of fibres: (3) 210-250μm (1) 100-120 μm (1) 350 µm
- Lines of xylem: 600-650 µm in Width.

FIBRE VOLUME FRACTION (V_F)- DIGITAL IMAGE PROCESS (DIP)










TENSILE TEST SPECIMEN



DG Bamboo 4 years old

1125 specimens (375 for each $V_{\rm f}$)

15 specimens being tested for each moisture content at both room temperature and frozen conditions

1035 specimens were immersed in distilled water to increase moisture content

23°C and 40% respectively

MOISTURE ABSORPTION



-Submerged in distilled water at normal conditions and at 23°C.

-7 samples - Moisture meter (Promtimeter MMS).

-85% moisture content at 80 days, 125 days and 167 days.

- The moisture absorption data results show that the kinetics of absorption, and the moisture content at equilibrium distinctly increase with increasing V_f .

MOISTURE CONTENT EFFECTS ON TENSILE STRESS-STRAIN



-The samples containing V_f 57.4%, 52.3% and 47.4% failed showing linear stress-strain from the beginning of loading to the breaking point when the level of moisture content was lower than 5%, 4% and 3% respectively.

- With variation in moisture level content the stress-strain behaviour of the DG bamboo samples can be grouped into three types:

MOISTURE CONTENT EFFECTS ON TENSILE STRESS-STRAIN



MOISTURE CONTENT EFFECTS ON TENSILE MODULUS OF ELASTICITY (TMOE)



-In general, the moisture content effects on TMOE on DG bamboo layers are independent of V_f studied.

- Therefore the modulus variation for all of them can be classified in four regions, where three are following an accentuated decreasing logarithmic curve and one a gently decreasing linear function.

Bamboo as concrete reinforcement in hydroelectric structures

Science and Construction





Bamboo as concrete reinforcement in hydroelectric structures



Powerhouse for Hydroelectric Plant



Analysis of a powerhouse structure using Finite Element Method



Steel reinforcement for walls and slabs in powerhouses



Detail study in the development of bamboo space structure





The objective of the bamboo researches are to establish its physical and mechanical behavior making possible its employment as a substitute of the structural steel.



Detail study in the development of bamboo space structure



Since 1979 the behavior of low cost, low energy consuming and large availability materials, that could be used in the construction industry, have been researched.

Ph.D. thesis Luis Eustaquio Moreira PUC-Rio









TNL





Bamboo pedestrian bridge built for local community by Belgian architect Sven Mouton and engineers in collaboration with NOCMAT research group of PUC-Rio

Ubatuba – São



















INTRODUCTION







Treliça-carro





Demoiselle airplane built and commercialized by Santos Dumont in 1906



Structure made of bamboo and cables made of piano cords.

DYNAMIC TESTS



DYNAMIC TESTS



Aínda precisa capacete de Bambu para o Carro do bambu...



T4: Laminated Bamboo false ceiling



T4: Laminated Bamboo false ceiling

film

T4: Laminated Bamboo false ceiling



Recent Applications of Non-Conventional Materials in Brazil and in the World



The recent publications of PUC-Rio & other national international institutions provid information to the first applications of the studied materials.



Cozumel night club-RJ

zumel night club during its construction-RJ
Bamboo house in Itanhangá, Rio de Janeiro-RJ



Serious problems, Creative solutions



Capela de Andrelandia, M.G Jose Luiz Mendes Ripper PUC Rio



Capela de Andrelandia, M.G Jose Luiz Mendes Ripper PUC Rio

Andrelândia, M.G.

Reference number of committee draft: ISO/TC 165/ N 313

Date: 2001-11-21

Reference number of document: ISO/DIS -22156

Committee identification: ISO/TC 165/WG 9

Secretariat: SCC

Bamboo Structural Design

Titre — Titre — Partie n: Titre de la partie

Bambou - design pour usage structurel

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Reference number of working document: ISO/TC 165 N315

Date: 2001-12-07

Reference number of document:

Committee identification: ISO/TC 165/WG 9 Secretariat: SCC

Laboratory Manual on Testing Methods for Determination of physical and mechanical properties of bamboo

Rapport Laboratoire d'Essai pour Détermination des propriétés physiques et mécaniques du bambou

© ISO 1999 – All rights reserved

Reference number of committee draft: ISO/TC165N314

Date: 2001-11-28

Reference number of document: ISO/DIS- 22157

Committee identification: ISO/TC 165/WG9

Secretariat: SCC

Determination of physical and mechanical properties of bamboo

Titre — Titre — Partie n: Titre de la partie

Détermination des propriétés physiques et mécaniques du bambou

Distribution of fibers in the nodal region of Phyllostachys Edulis Bamboo (Moso)



Axis in respect to longitudinal, circumferential and radial directions







anastomoses

Analysis of the meso-structure of bamboo using an Astra Umax 2200 scanner and the NIH Image J software.



Atomic Force Microscopy (AFM) 50.0 Datā sc 25.0 40 30 20 25.0 50.0 0 10 (b) Surface of vascular bundles in 3-D (a) Surface of vascular bundles in 2-D image image A Veeco_DI 3100 Nanoscope AFM system was used in the tapping mode

to characterize surface topography of the fiber bundles.

50.0

Future Buildings (Nano Arhitecture Barcelona, Marko -Spain)



Future Buildings (Nano Arhitecture Barcelona Marko - Spain)



Future Buildings (Nano Arhitecture Barcelona Marko - Spain)



Advanced bamboo structural performance througl impregnation of compatible



Detail of the polymer treated bamboo applied to Nano - Architecture.

Streets and Houses in the town of Bam Persia (Iran) Semi desert Area

Using soil fibers and adapting achitecture of the town according to existing nature



Streets and Houses in the town of Bam Persia (Iran) Semi desert Area

Using soil fibers and adapting achitecture of the town according to existing nature









The manual methods of production of ice during winter in Iran (Persia).

Soil Reinforced with Vegetable fibers

Executed at UFPB

SOLO-CAL

SOLO-FIBRA

SOLD NATURAL

Soil blocks after testing



SOLO-FIBRA-CAL

SOLD NATURAL















The General Panorama

Production

Modeling Process & Simulation Tooling, Fabrication, Assembly

Materials Characterization Stiffness, Strength, Toughness Cost Analysis Cost/Perfomance Trade-offs

Performance Evaluation Durability, Damage Tolerance

Durability Analysis of Component

Initial Imperfection Deformation Models Stress - Strain Analysis Stress/strain/Temp at Critical Sites

Damage Mechanisms Matrix Cracking, Delamination, Visco - elasticity/aging, etc.

Stiffness Degradation Damage Mechanics Micro/Meso/Macro Models

Strength Degradation

Service

Loading

Flife Prediction

Pupunha (Bactris gasipaes)

- Alternativa sustentável à exploração extrativista de espécies nativas da Mata Atlântica
- Produção em crescimento
- Oportunidade: constatação da falta de opções em escala para escoamento do refugo



Design: Juliana Cesário e Cláudio Amorim







Design: Fibra + LETS EVO



Skate de laminado de Bambu e Pupunha



Análise comparativa das amostras de Pupunha

 O processamento foi feito com o objetivo de identificar e agrupar as distintas fases constituintes do material e calcular, pela comparação entre áreas sua fração volumétrica





Fração volumétrica de fibras = 0,5143





Fração volumétrica de fibras = 0,6343

Análise do gradiente de concentração de fibras ao longo da espessura do estipe



ABMTEThe NC site Today It is in English and Portuguese

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- Membership
- Registration
- Research Areas
- Bulletin
- Events
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ABMTENC Areas of Work - Today



New model of bamboo Bike developed at PUC-Rio under supervision of Profs: Khosrow Ghavami and Jose Luis Ripper







Obrigado Muchas Gracias

Thank You Merci





14° IC-NOCMAT 2013

João Pessoa, Paraíba, Brasil Mars 24 to 27 /2013







After last NOCMAT conferences in Bath-UK, Cairo Egypt, Changsha-Chine the 14NOCMAT will be held in Joao Pessoa Brazil! The 14th IC-NOCMAT 2013 will be held in João Pessoa, during 24-27 March 2013. We are looking forward to see you there . Prof. Khosrow . Ghavami – PUC-Rio Prof. Normando Perazzo Barbosa - UFPB









