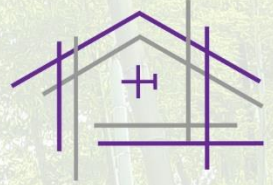




IC-NOCMAT 2019



18th International Conference on Non-Conventional Materials and Technologies

July 24th - 26th, 2019

University of Nairobi Towers
Nairobi, Kenya

BOOK OF ABSTRACTS



PPCEM
POST-GRADUATION PROGRAMM ON
SCIENCE AND MATERIALS ENGINEERING
FEDERAL UNIVERSITY OF PARAÍBA, BRAZIL



PennState
College of Engineering
ARCHITECTURAL
ENGINEERING

Normando Perazzo Barbosa

Khosrow Ghavami

Esther Adhiambo Obonyo

José Augusto Gomes Neto

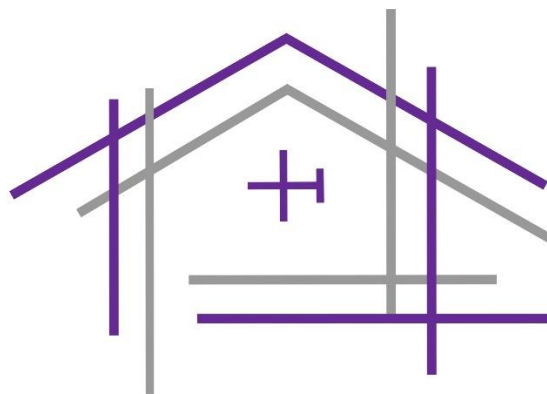
BOOK OF ABSTRACTS

18th INTERNATIONAL CONFERENCE ON NON-CONVENTIONAL MATERIALS AND TECHNOLOGIES – IC NOCMAT 2019

Nairobi, Kenya

July, 24th – 26th, 2019

University of Nairobi



IC-NOCMAT 2019

1st Edition

João Pessoa – Paraíba – Brazil
2019



Copyright © by Normando Perazzo Barbosa

Review

Normando Perazzo Barbosa
José Augusto Gomes Neto

Cover

José Augusto Gomes Neto

Editorial Board

Normando Perazzo Barbosa
José Augusto Gomes Neto
Esther Adhiambo Obonyo
Khosrow Ghavami

Barbosa, N. P.
Book of abstracts of 18th international conference on non-
conventional materials and technologies – IC NOCMAT 2019
Nairobi, Kenya, 2019
60 p.

ISBN: 978-65-81063-00-9

1. IC-NOCMAT 2019. 2. Book of abstracts.

UFPB

Printed in Brazil - 2019

Conference Chairs / Co-chairs

- Dr. Esther Obonyo – The Pennsylvania State University
- Dr. Khosrow Ghavami – ABMTENC – Rio, PUC-Rio

Local Organizing Committee Chair / Co-chairs

- Patts Odira – University of Nairobi
- Dr. Titus Kivaa – Jomo Kenyatta University of Agriculture & Technology
- Q.S. James Okaka – Jomo Kenyatta University of Agriculture & Technology
- Eng. Moses Opiyo – Kenyatta University

Scientific Committee

- Prof. Said Kenai, University Saad Dahlab
- Prof. Beatriz Garzon, University of Tucuman
- Dr. Conrado de Sousa Rodrigues, Federal Institute of Minas Gerais
- Prof. Holmer Savastano Jr., University of São Paulo / USP - Pirassununga
- Assoc. Prof. Luis Eustáquio Moreira, Federal University of Minas Gerais
- Prof. Normando Perazzo Barbosa, Federal University of Paraíba
- Prof. Pierre Ohayon, Federal University of Rio de Janeiro
- Prof. Romildo Dias Toledo Filho, Federal University of Rio de Janeiro
- Dr. Ulisses Targino Bezerra, Paraíba Federal Institute of Paraíba
- Dr. Aluisio Braz Melo, Federal University of Paraíba
- Prof. Milton Bezerra das Chagas Filho, Federal University of Campina Grande
- Prof. Antonio Beraldo, University of Campinas.
- Prof. Jianzhuang Xiao, Tongji University
- Prof. Yan Xiao (China/USA) Zhejiang University/U. of Southern California
- Prof. Jianzhuang Xiao, Tongji University
- Prof. Eduardo Moreira, Central University of las Villas- Cuba,
- Dra. Lena Mora, Central University of las Villas.
- Prof. Hanan El Nouhy, Housing and Building National Research Center / HBRC
- Prof. Jean-Claude Morel, École Nationale des Travaux Publics/Coventry University
- Prof. B.V. Venkatarama Reddy, Indian Institute of Science, Bangalore
- Assoc. Prof. Kambiz Pourtahmasi, University of Tehran
- Prof. Mohamad Zaman Kabir, Amirkabir University of Technology, Tehran
- Prof. Giorgio Monti, Sapienza University of Rome
- Prof. Manuela Mattone, Polytechnic of Turin
- Prof. Alejandro Manzano-Ramírez, CINVESTAV-IPN
- Prof. Pedro Jesús Herrera, Yucatan's Center for Scientific Research
- Prof. Piet Stroeve, University of Delft
- Prof. Antônio Tadeu – University of Coimbra
- Prof. José Barroso Aguiar, University of Minho
- Prof. Humberto Varum – University of Porto
- Prof. G. I. Yakoviev, Kalashnikov Izhevsk State Technical University Stencheskaya
- Dr. Jorge Juan Payá Bernabeu, Universidad Politécnica de Valencia
- Dr. José María Monzó Balbuena, Universidad Politécnica de Valencia
- Dr. Angel Palomo, Instituto Eduardo Torroja
- Prof. Mitchell Gohnert, University of the Witwatersrand / Johannesburg.
- Prof. G. Habert, Zurich Polytechnic
- Prof. J. V. Tesha, University of Dar es Salaam
- Prof. Pete Walker, University of Bath
- Dan Maskell, University of Bath
- Dr. Bruce King, Sustainable Design and Engineering
- Prof. Kent A. Harries, University of Pittsburgh

PREFACE

The IC-NOCMAT series provides an international forum for information dissemination and exchange, discussions, and debates on research and practice in a range of sustainable and innovative construction materials and technologies. The first NOCMAT held in 1984 in Rio de Janeiro, organized by Prof. Khosrow Ghavami, who already was preoccupied at that time with the impact of industrialized construction materials on the environment. In 1990, Prof. Ghavami created the Brazilian Association of Non-conventional Materials and Technologies, ABMTENC. Since then, the association has held NOCMAT conferences around the world.

The tropical countries are extremely rich in natural materials and appropriate local technologies. In those countries, with the increase of industrialization and the domination of big polluting industries, and through the implementation of corrupt administration the ecological local industries forgotten. Now, when environmental pollution problems involve the whole world, the interest to study the denominated non-conventional materials and Technologies, NOCMAT, becomes a necessity.

The NOCMAT 2019, that is the 18th edition of the NOCMAT series, in Nairobi, Kenya, attracted a wide range of academics, scientists, researchers, students, builders, designers, NGO field-workers, besides other industrialists from a wide variety of backgrounds, including fields of architecture, engineering, materials, sustainable and ecological technologies, biomaterials, materials sciences, and environmental engineering. The conference also was of interest to specialists in geography, economists and administrators of natural resources.

Acknowledgements



SUMMARY

| | |
|---|-----------|
| BIO-MATERIALS | 1 |
| EXTRACTION OF SILICA PRESENT IN RESIDUAL SUGAR CANE BAGASSE ASH... | 3 |
| NATURAL FIBRES AS CEMENTITIOUS COMPOSITES REINFORCEMENT | 4 |
| INNOVATIVE SANDWICH PANELS MADE OF WOOD BIO-CONCRETES AND SISAL REINFORCED CEMENT COMPOSITES | 6 |
| ASSESSING THE MECHANICAL PROPERTIES OF BAMBOO CULTIVATED IN ITALY | 7 |
| CARBON FOOTPRINT AND WATER SCARCITY ASSESSMENT OF WOOD BIO- CONCRETES: EVALUATION OF DIFFERENT LIFE CYCLE IMPACT METHODS | 8 |
| STABILIZED COMPRESSED EARTH BLOCKS WITH TERNARY BINDER | 9 |
| STANDARDS, SPECIFICATIONS & INFORMATICS | 10 |
| THE POTENTIAL UTILITY OF MATERIALS INFORMATICS IN DEVELOPING NON- CONVENTIONAL MATERIALS | 11 |
| NEGOTIATING THE STANDARDS MAZE TO ENABLE THE USE OF NOVEL CONSTRUCTION MATERIALS | 12 |
| DEVELOPMENT OF A BAMBOO DESIGN STANDARD FOR THE 21ST CENTURY.. | 13 |
| PHYSICAL AND MECHANICAL BEHAVIOR OF POLYVINYL ALCOHOL IMPREGNATED PHYLLOSTACHYS PUBESCENS (MOSSO) BAMBOO | 14 |
| DEVELOPMENT OF PRECAST PLASTER ELEMENTS USING WOOD WASTE AND GLASS WASTE | 15 |
| CHALLENGES AND OPPORTUNITIES FOR THE USE OF EXCAVATION MATERIAL IN THE BUILT ENVIRONMENT. A CASE-STUDY IN COLOMBIA..... | 16 |
| DEVELOPING A PANELIZED BUILDING SYSTEM FOR LOW-COST HOUSING USING WASTE CARDBOARD AND REPURPOSED WOOD | 17 |
| ANALYSIS OF SCIENTIFIC PRODUCTION IN THE SCOPE OF THE BRAZILIAN NATIONAL NETWORK FOR RESEARCH AND DEVELOPMENT OF BAMBU - REDEBAMBU/BR: BIBLIOMETRY AND SOCIAL NETWORKS..... | 18 |
| BIBLIOMETRIC ANALYSIS OF SCIENTIFIC AND TECHNICAL PAPERS WITHIN NOCMAT 1984-2017 INTERNATIONAL CONFERENCES | 19 |
| ANALYZING FIVE EVALUATION APPROACHES FOR R&D PROJECTS WITHIN THE BRAZILIAN NATIONAL BAMBOO'S NETWORK – REDEBAMBU/BR | 20 |
| DESIGNING & BUILDING WITH BAMBOO | 21 |

| | |
|--|-----------|
| EXPERIMENTS WITH PARTS OF RINGS TO DETERMINE THE INNER AND OUTER CIRCUNFERENTIAL STRENGTH OF BAMBOO..... | 21 |
| ANALYSIS OF BOND-BEHAVIOR OF BAMBOO STRIP AND BAMBOO BIO-CONCRETE..... | 23 |
| FULL-CULM BAMBOO AS A FULL-FLEDGED ENGINEERING MATERIAL | 24 |
| SCREW WITHDRAWAL CAPACITY IN FULL-CULM BAMBOO..... | 25 |
| NON-CONVENTIONAL MATERIALS / TECHNOLOGIES & RESILIENCE.. | 26 |
| RWANDA INSTITUTE FOR CONSERVATION AGRICULTURE: LESSONS LEARNT DESIGNING EARTH WALLS TO CODE IN A MODERATE SEISMIC ZONE | 27 |
| ANALYSIS OF EARTHQUAKE TESTING TRENDS OF ALTERNATIVE BUILDING MATERIALS | 28 |
| SOCIAL HOUSING ON EARTH AND BIOENVIRONMENTAL RESILIENCE: TWO CASES IN TUCUMÁN, ARGENTINA..... | 29 |
| CONCRETE & CEMENTITIOUS MATERIALS | 30 |
| SELF-COMPACTING CONCRETES USING CALCIUM-RICH ASHES AS ALTERNATIVE FILLERS | 32 |
| EFFECTS OF TEMPERATURE IN SELF-COMPACTING CONCRETES USING CALCIUM-RICH ASHES AS ALTERNATIVE FILLERS | 33 |
| FROM PRESCRIPTIVE TO PERFORMANCE BASED DURABILITY DESIGN AND SPECIFICATION OF CONCRETE STRUCTURES..... | 34 |
| COMPARATIVE STUDY BETWEEN PROPERTIES OF GEOPOLYMERIC CEMENTS PRODUCED WITH DIFFERENT TYPES OF METAKAOLIN..... | 36 |
| THE INFLUENCE OF WOOD SHAVINGS TREATMENTS ON THEIR COMPATIBILITY WITH CEMENTITIOUS MATRIX | 37 |
| BAMBOO REINFORCED CONCRETE: LESSON LEARNED, PROHIBITIONS AND OPPORTUNITIES | 38 |
| INFLUENCE OF PORCELAIN TILE POLISHING RESIDUES AS A SUPPLEMENTARY CEMENTITIOUS MATERIAL IN CONCRETE | 39 |
| SOCIAL, ECONOMIC & CULTURAL DIMENSIONS | 40 |
| AFFORDABILITY AND SUSTAINABILITY OF NON-CONVECTIONAL CONSTRUCTION MATERIALS IN KENYA..... | 41 |
| APPLICATION OF ALTERNATE CONSTRUCTION TECHNIQUES INREHABILITATION OF URBAN SLUMS..... | 42 |

| | |
|--|-----------|
| A STUDY OF THE SOCIO-ECONOMIC CULTURAL AND ENVIRONMENTAL IMPACT OF THE USE OF UNCONVENTIONAL BUILDING MATERIALS IN CONVENTIONAL BUILDING TYPOLOGIES | 43 |
| USE OF NON-CONVENTIONAL MATERIAL IN THE BUILDINGS OF THE ITAMARATI FARM, BEFORE AND AFTER THE ADAPTATIONS TO THE MODEL OF RURAL SETTLEMENTS MANAGED BY INCRA. | 44 |
| INFLUENCE FACTORS AFFECTING THE ADOPTION OF NON CONVENTIONAL MATERIALS IN THE RURAL DWELLINGS, SOUTH MATO GROSSO, BRAZIL | 45 |
| SOIL BUILDING BLOCKS STABILIZED WITH WHEAT STRAW AND CEMENT | 46 |
| THE POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK FOR ADOPTION OF INNOVATIVE BUILDING TECHNOLOGIES IN KENYA | 47 |
| MATERIALS WITH HIGH DENSITY / THERMAL MASS | 48 |
| CASE STUDY ON SMALL COMPANIES OF ORNAMENTAL STONE PROCESSING IN THE CITY OF MONTEIRO - PARAÍBA – BRAZIL | 49 |
| RE-DESIGN PROPOSAL FOR THE THERMAL AND ENERGETIC EFFICIENCY OF A PRIMARY HEALTH CENTER IN TUCUMÁN, ARGENTINA..... | 50 |
| ABSORBENT MATERIALS FOR CLASSROOMS REVERBERATION CONTROL IN CLASSROOMS OF SAN MIGUEL DE TUCUMÁN. PARAMETERS DETERMINATION AND COMPARISON..... | 51 |
| A BAMBOO DESIGN CONCEPT FOR LOW-INCOME HOUSING IN KENYA..... | 52 |



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

BIO-MATERIALS





*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

MONOLITHIC MYCELIUM: GROWING VAULT STRUCTURES

Jonathan Dessi-Olive¹

¹ Georgia Institute of Technology School of Architecture, Atlanta, GA, USA;

ABSTRACT

This paper presents advancements in mycelium construction, demonstrated through a large-scale monolithic mycelium vault structure. In the burgeoning field of bio-materials, mycelium has emerged as a potentially viable building material because it is naturally occurring, demands little energy for its production, is lightweight, and completely bio-degradable. Whereas, previous architecture-scale mycelium constructions used component-based techniques, this paper presents novel research on grown-in-place and self-supporting *monolithic mycelium structures*, achieved using techniques resembling common practices for cast-in-place concrete.

EXTRACTION OF SILICA PRESENT IN RESIDUAL SUGAR CANE BAGASSE ASH

**Primo Fernandes Filho¹, Sandro Marden¹, Normando Perazzo Barbosa¹, Kelly
Cristiane Gomes da Silva¹, Paloma Alcântara²**

¹ Prof. Center of Technology of Federal University of Paraíba, João Pessoa, Brazil;

² PhD Student, Federal University of Paraíba

ABSTRACT

After chemical characterization of the residual sugar cane bagasse ash (CBC), it was found that silica contributes with 71% of its composition. In this paper, we intend to determine the yield of soluble silica, contained in the residue, and the consequent potential for its use as a source of silica in the production of cement products. The methodology adopted for silica extraction takes into account that amorphous silica increases its solubility in high pH solutions and as a consequence, in the presence of acid solution, the silica present in the alkali silicate is precipitated. The physical characterization evaluated the density using the Pycnometer and the specific area using the Blaine equipment. The chemical characterization determined the composition in oxides through the technique of x-ray fluorescence spectroscopy and the mineralogical characterization resorted to the techniques of infrared spectroscopy and x-ray diffraction to identify the phases present in the samples. To give significance to the silica yield extracted from the residual ash, the result was compared to the silica yield extracted from samples of other materials, taken as reference, for example of metakaolin (META), and quartz (QP), using same method. The results were 2.89% (QP), 11.94% (CBC) and 34.17% (META). Considering the volume of available raw material, the result is encouraging and can be increased, from the amorphous character improvement, such as: more efficient washing of the sugar cane and controlled burning of the bagasse. A milling process aiming to increase the fineness of the material may also contribute to the increased yield of the extracted silica.

NATURAL FIBRES AS CEMENTITIOUS COMPOSITES REINFORCEMENT

**Jerônimo Coura-Sobrinho¹, Camila Lacerda Gomes¹, Conrado de Souza
Rodrigues¹, Mário Guimarães Júnior¹**

¹ Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG), Brazil;

ABSTRACT

The ban on the use of asbestos as reinforcement of cementitious composites in some countries and the scarcity of asbestos in nature have stimulated research on the use of alternative fibres to replace that mineral. Unlike asbestos, natural fibers are eco-friendly and therefore present as a low cost alternative due to their availability. On the other hand, the production of natural fibre reinforced cementitious composites requires special care both to ensure the quality of the interface between the matrix and the reinforcement and to minimize the effects of alkaline attacks. The most tested natural fibres in composites are sisal, jute, curauá, cotton, flax, hemp, ramie, bamboo and plants such as eucalyptus and pine. Researches have assessed the mechanical performance and the durability of the composites with alternative fibres, in the search of compositions that guarantee the compatible characteristics to the applications of the cementitious composite. The chemical composition of natural fibres of vegetable origin (cellulose, hemicellulose and lignin), besides being responsible for the adhesion with the cement matrix, is also susceptible to alkaline attacks, causing the degradation of the reinforcement and consequent decrease of the durability of the composite. These factors are the major challenges for researchers in the field. This work has the objective of analyzing the effects of the addition of two reinforcements - jute mesh and microfiber of vegetal origin - in the tenacity of fiber cement. To minimize alkaline attack on the fibres, 15% of the cement was replaced by rice husk ash (RHA). In order to minimize the degradation of the reinforcements the jute mesh was submitted to bleaching in a solution of sodium hydroxide and hydrogen peroxide. The results of the mechanical tests showed that the combination of mesh jute and pinus microfiber consists of a promising reinforcement of cementitious composites.

CHEMICAL COMPOSITION AND SELECTED PHYSICAL CHARACTERISTICS OF NEEM SEED HUSK ASH BLENDED CEMENT

A. A. Raheem¹, B. D. Ikotun¹, E. O Ibiwoye²

¹ Department of Civil and Chemical Engineering, University of South Africa;

² Department of Civil Engineering, Ladoke Akintola University of Technology (LAUTECH) Ogbomosho, Nigeria;

ABSTRACT

Neem tree (*Azadirachta indica*) is a tropical evergreen tree scattered all over Nigeria. Production of neem oil from the seed generates large quantity of residue annually which constitutes a waste disposal problem. The residue can be converted into Neem Seed Husk Ash (NSHA) and used as partial substitution for cement in the production of concrete. This study investigated the characteristics of NSHA blended cement produced in the factory. Neem fruits were collected from Olooru town and Ilorin metropolis in Kwara State Nigeria and the seeds were burnt in a furnace at a temperature of 650 ± 50 °C and the chemical composition (SiO_2 , Al_2O_3 and Fe_2O_3) determined. Blended cement was produced by intergrinding 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50% by weight of NSHA with Ordinary Portland Cement (OPC) clinker and gypsum. The blended cements produced were analyzed for chemical composition (SiO_2 , Al_2O_3 , Fe_2O_3 , CaO) and physical properties (fineness, initial and final setting time, heat of hydration). The total percentage of SiO_2 , Al_2O_3 and Fe_2O_3 for NSHA is 75.35%. The percentage of SiO_2 , Al_2O_3 , Fe_2O_3 and CaO for blended cement with 5% - 50% ash replacements ranged from 20.21 – 20.81, 5.41 – 3.86, 3.21 – 1.92 and 62.76 – 42.48, respectively. The corresponding fineness (m^2/kg), initial and final setting time (min) and heat of hydration (cal/g) for the blended cement ranged 230 – 740, 45 – 72, 135 – 235, and 34 - 49, respectively. Factory produced NSHA – blended cement is suitable as it satisfied maximum requirements.

INNOVATIVE SANDWICH PANELS MADE OF WOOD BIO-CONCRETES AND SISAL REINFORCED CEMENT COMPOSITES

**M'hamed Y. R. Da Gloria¹, Daniele O. J. dos Santos¹, Vanessa M. Andreola¹,
Romildo D. Toledo Filho¹**

¹ Department of Civil Engineering, COPPE, University Federal of Rio de Janeiro, University City, RJ,
Brazil;

ABSTRACT

In this study, sandwich panels were produced with two lightweight cores containing wood bioconcretes, and facings in laminate mortar reinforced with long sisal fibers. To produce the core, two cement-to-wood mass ratios of 0.5 and 2.5 were used to analyze the behavior of the panels, with high and low wood shavings content. The facings were produced with 6% of long sisal fibers reinforcing a cementitious mortar free of calcium hydroxide. The density and longitudinal compressive behavior of the sandwich panels were accessed. The results showed that the panels could be considered as lightweight for presenting densities lower than 1500 kg/m³. Besides, the panel with low wood shavings content was more resistant and presented a better bond between the core and the laminates. Globally, the bio-based sandwich panels demonstrated technical potentiality for multi-use in wall system, and offered new range of use of vegetables in cementitious matrices.

Keywords: Sandwich Panels, Cement, Wood Shavings, Long Sisal Fibers, Wood BioConcretes.

ASSESSING THE MECHANICAL PROPERTIES OF BAMBOO CULTIVATED IN ITALY

Silvia Greco¹, Luisa Molari¹, Mirko Maraldi²

¹ DICAM, University of Bologna, Bologna, Italy;

² DISTAL, University of Bologna, Bologna, Italy;

ABSTRACT

The excellent mechanical performance of bamboo, coupled with its sustainability, have boosted the use of this plant as a structural material in the last decades. There are countries in which this material has been used in construction for millennia and represents an asset. On the other hand, there are countries where still there is not enough knowledge of the structural properties of locally-grown bamboo. The available studies and data in the literature refer to American or Asian bamboo, and constructions in other parts of the world are made with these imported materials. Expanding the knowledge of bamboo mechanical properties to other species can facilitate its diffusion as a structural material in parts of the world where bamboo is not traditional as such. In order to accomplish this, a very important step is the development of standardised testing procedures. In this paper, the results of an experimental campaign for the mechanical characterization of *Phyllostachys Viridiglaucescens* grown in Italy is presented. This species is one of the most common bamboo species cultivated in temperate climate. Compressive tests, tensile tests, shear tests and bending tests were performed. The methodology is mainly compliant with the International Standards; however, to cope with the particular physical properties of Italian bamboo, the testing methodology was modified, where needed, with respect to that prescribed by the International Standards.

Keywords: *Phyllostachys Viridiglaucescens*, Mechanical properties, European bamboo.

CARBON FOOTPRINT AND WATER SCARCITY ASSESSMENT OF WOOD BIO-CONCRETES: EVALUATION OF DIFFERENT LIFE CYCLE IMPACT METHODS

Lucas R. Caldas¹, Ana. Paula N. Menezes¹, M'hamed Y. R. Da Gloria¹, Vanessa M. Andreola¹, Daniele J. Santos¹, Romildo D. Toledo Filho¹

¹ Department of Civil Engineering, COPPE, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil;

ABSTRACT

Normally, when bio-based materials are used as aggregates, especially wood shavings, and mixed with cementitious materials, it may have setting problems due to the extractives that are present in these materials. One alternative to solve this problem is the process of washing the bio aggregates in hot water and sometimes setting accelerators can be used. On the other hand, these processes and products can increase the environmental impacts of the bio-concrete production, due to the water and energy consumption. Then, different alternative for the wood shavings (WS) treatment must be evaluated in terms of environmental impacts and mechanical performance. This paper aimed to evaluate environmental aspects and the relation with mechanical performance (using the compressive strength as indicator) of different mixes of a wood bio-concrete (WBC) that is being developed in Brazil. The greenhouse gases (GHG) emissions and Water Scarcity were evaluated. As a way to perform a sensitivity analysis of the study, we used different Life Cycle Impact Assessment (LCIA) methods. For the carbon footprint, the Dynamic LCA and IPCC at 100 years were employed. For the Water Scarcity, we applied four methods: (1) Pfister, (2) Boulay, (3) Hoekstra and (4) Berger. The modelling was performed in the SimaPro software using the Ecoinvent database adapted to the Brazilian context. When the mechanical performance indicator was used, the WBC produced with not washed WS and CaCl₂ (NW_A) mixture presented the best results, for the carbon footprint and water scarcity assessment. Even with use of different LCIA methods, the results pointed out that the NW_A mixture was the best option. This study showed that the wood shavings treatment is an important stage in the wood bio-concrete production and deserve special attention, mainly in relation to the water consumption.

Keywords: Wood bio-concrete, Dynamic LCA, LCIA Methods.



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

STABILIZED COMPRESSED EARTH BLOCKS WITH TERNARY BINDER

Marvin Grover Alvarado Figueroa¹, Javier Quiñónez ²

¹ Civil Engineers Co.;

² San Carlos University of Guatemala;

ABSTRACT

This document presents the experimental results in manufacture of compressed earth blocks with natural lightweight aggregates, using clay as main binder and a ternary material composed of high early strength hydraulic (HES) cement, calcium hydroxide and a local volcanic pozzolan, as a specific stabilizer of the main binder (clay). It also includes the evaluation of the physical characteristics and mechanical properties of blocks, according to the procedures and standards established by international regulations. The chemical and physical characterization tests of raw materials were made in specific laboratories of the Engineering Research Center at University of San Carlos of Guatemala. The blocks were manufactured with electric drive hydraulic equipment, available in a private company. Different dosages of natural volcanic aggregates, binder and stabilizing ternary material were used. The units were cured for 3 days using water at room temperature. The investigation records values of compressive strength for ages from 7 to 100 days; results of other tests required by international regulations are also included. The best compressive strength results were 5.1 MPa for 36 days edge. These results will allow the production of construction elements that reduce the environmental impact and provide a safe and affordable construction.



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

STANDARDS, SPECIFICATIONS & INFORMATICS





*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

THE POTENTIAL UTILITY OF MATERIALS INFORMATICS IN DEVELOPING NON-CONVENTIONAL MATERIALS

Chuyuan Zheng¹, Yusuf Akintayo Akinbade², Ian Nettleship¹, Kent Harries²

¹ Department of Mechanical Engineering and Materials Science;

² Department of Civil and Environmental Engineering, Swanson School of Engineering, University of Pittsburgh, USA;

ABSTRACT

Materials informatics is widely acknowledged as a means of accelerating the rate of new materials discovery and material development. Such an approach will require widespread use of data driven methodologies and it is anticipated that downstream stakeholders, particularly industry, will be heavily involved in providing the required resources. This paper will propose workflows that illustrate how data driven methods could reasonably be applied to the processing-structure-properties relationships of locally sourced non-conventional materials. It is anticipated that simple material tests and imaging techniques will provide sufficient digital information for data driven approaches at relatively low cost. This utility will be illustrated using the example of bamboo and the levels of structure observable using widely available digital phone cameras. Finally, the possible role of the NOCMAT community in facilitating materials informatics will be considered.

Keywords: Non-Conventional, Materials, Informatics.



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

NEGOTIATING THE STANDARDS MAZE TO ENABLE THE USE OF NOVEL CONSTRUCTION MATERIALS

Saad S. Yahya

University of Nairobi

ABSTRACT

One attribute of a cultured and organized sedentary community is the existence of rules and regulating on how buildings and supporting services should be constructed. And these rules get more complex as time passes, mainly because of changes in demographics, prosperity (or otherwise), lifestyle trends, technological advance and so on. Then there are new construction materials being developed and old materials finding new uses. And that is the essence of sustainability, that is making the future more livable and today's comforts and safety durable. It is for that reason that regulatory regimes and practice codes are essential. This paper reflects on the efforts of government and municipalities, especially Kenyan, to design and administer appropriate standards and building codes that will suit the diverse needs of citizens and industry, while not forgetting the staggering levels of social inequality. Much of the material comes from research work done in the period 2016-18 on first, standards for basic infrastructure in unplanned settlements in five cities; and secondly investigations to support the development of a housing policy for the City of Nairobi. Both initiatives were sponsored by the government of Kenya.



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

DEVELOPMENT OF A BAMBOO DESIGN STANDARD FOR THE 21ST CENTURY

David Trujillo¹, Kent Harries², Sebastian Kaminski³

¹ Coventry University

² University of Pittsburgh

³ Arup

ABSTRACT

Since the beginning of the 21st century a number of bamboo structural design standards and codes have emerged throughout the world. Their usefulness to a structural engineer is wide ranging, though most are of limited use. Since 2015 the INBAR Bamboo Construction Task Force has pooled efforts from across the world in order to develop a new international suite of standards for the structural use of bamboo. The aim of this effort is to create the basis on which ‘modern’ structural design with bamboo can be undertaken. The characteristics of the suite of standards, particularly the thinking behind the revised ISO 22156, are discussed at length.

PHYSICAL AND MECHANICAL BEHAVIOR OF POLYVINYL ALCOHOL IMPREGNATED PHYLLOSTACHYS PUBESCENS (MOSSO) BAMBOO

**Lucas Muniz Valani¹, Fabrício de Campos Vitorino¹, Adriana Paiva de Souza
Martins¹, Romildo Dias Toledo Filho¹**

¹ Sustainability Center for Research and Education on Environmental Friendly Materials and Technologies - NUMATS, Civil Engineering Program, Universidade Federal do Rio de Janeiro, Brazil;

ABSTRACT

Bamboo have outstanding carbon sequestration potential and excellent mechanical properties, amongst natural construction materials. However, due to its hygroscopic, humidity and temperature sensitivity, its outdoor use is limited. Such conditions lead to longitudinal cracks formation. Cracks occurs in bamboo's wall as a consequence of a radial moisture gradient that generate stress perpendicularly to natural fiber alignment. Moisture gradient is related to bamboo's microstructure, composed of vessels, fibers and parenchyma which densifies from inside to outside walls. Aiming to minimize aforesaid problems and to enhance mechanical properties, polyvinyl alcohol (PVOH) was used to impregnate strips of Phyllostachys Pubescens (Mosso) bamboo. Different impregnation temperatures (23, 60 and 100°C) were used to find the most effective polymer penetration. An optical active dye was mixed with PVOH to evidence the depth of impregnation in bamboo's wall thickness. Water absorption tests were carried out in plain and impregnated samples to evaluate the PVOH impregnation efficiency. Further, tensile mechanical tests were performed on most efficient impregnated specimen, to understand how PVOH affect this property. The results have shown that the optimal impregnation temperature was 60°C which led to a water absorption reduction of 33%. PVOH also affected the tensile mechanical behavior as compared to non-impregnated bamboo.

Keywords: Bamboo; Polyvinyl Alcohol; Impregnation; Physical Properties; Mechanical Behavior.

DEVELOPMENT OF PRECAST PLASTER ELEMENTS USING WOOD WASTE AND GLASS WASTE

Thibério César de Souza Vieira Lima¹, Eduardo da Cruz Teixeira¹, Marcos Antônio Padilha Júnior¹, Normando Perazzo Barbosa², André Luiz Santos Patriota¹

¹ Instituto Federal do Sertão Pernambucano, Salgueiro – PE, Brazil;

² Universidade Federal da Paraíba – UFPB – Brazil;

ABSTRACT

This paper aims at the development of precast elements of gypsum, wood residues produced by carpenters and glass residues were collected from the city of Salgueiro in northeastern Brazil. Were produced boards with the following dimensions (40x50, 33x33, 36x36 cm) were developed. After the collection of the residues, the tests of specific mass, grain size composition, pick time and apparent density were carried out. With the purpose of analyzing the mechanical resistance of the product resulting from the addition of gypsum with residues, 02 sample families were produced, the first consisting of gypsum and wood residue, and the second formed by the addition of gypsum and glass residues. Prototypes with 10% to 50% substitution of wood and vitreous silica residues were carried out, binder characterization tests were performed. with the reduction of gypsum and the addition of vitreous silica, thus contributing to a considerable reduction of environmental impacts. It was noted that the glass residues have good compactness. With the particle size analysis, it can also be concluded that the glass debris has well graded granulometry. The residue of the wood powder presents a grain size curve with continuous development. We performed substitutions of the gypsum mass for the corresponding volume of the wood residues, with the realization of the prototypes and possible to observe that the wood leaves a brownish aspect, already for the glass continues with the aspects of being only plaster. of time of handle, in which it can be observed that the binder has fast drying, making possible the production of precast elements.

CHALLENGES AND OPPORTUNITIES FOR THE USE OF EXCAVATION MATERIAL IN THE BUILT ENVIRONMENT. A CASE-STUDY IN COLOMBIA

Edwin Zea Escamilla¹, Gnanli Landrou⁴, Andrea Cifuentes Cuellar², Jesus Moreno³, Guillaume Habert⁴

¹ Centre for Corporate Responsibility and Sustainability, University of Zürich, Switzerland;

² Catholic University of Colombia, Design Faculty, Colombia;

³ University Santo Tomas, Architecture Faculty, Colombia;

⁴ Chair of Sustainable Construction, Swiss Federal Institute of Technology (ETHZ), Switzerland;

ABSTRACT

To steer towards sustainable development we require buildings and infrastructure. As consequence to the production of conventional construction materials large amounts of CO₂ are emitted to the atmosphere. Thus, to achieve sustainable development it is necessary to find construction technologies able to supply the demand of buildings and have low CO₂ emission. In this study we explore the challenges posed by the regulation for compulsory use of Construction and Demolition waste from buildings in Colombia, especially in housing projects. Furthermore, we identify the opportunities related to this newly created material demand. Moreover, the quantities of potential material produced were calculated and related to the requirements of the Colombian Norm 0472 for use of C&D waste. These results showed that a significant amount of conventional materials can be replaced. To evaluate the environmental impact of this replacement a comparative life cycle assessment was carried out. The software OpenLCA was used and the database ecovinvet 3.1, and the environmental impact assessment used the evaluation method from the Intergovernmental Panel for Climate Change "IPCC2013". This study shows that the challenges can only be overcome when engineered solutions can bring to scale the use of excavation material in contemporary architecture in terms of volume and price. Finally, by reducing the amount of CO₂ emission and presenting a potential economic savings, earth based construction materials can become a driver to achieve sustainable development.

Keywords: earth, excavation, materials, LCA, CO₂

DEVELOPING A PANELIZED BUILDING SYSTEM FOR LOW-COST HOUSING USING WASTE CARDBOARD AND REPURPOSED WOOD

Julio Diarte^{1,2}, Marcus Shaffer¹, Esther Obonyo¹

¹ Penn State University, University Park, PA, USA;

² National University of Asuncion, San Lorenzo, Paraguay;

ABSTRACT

This paper presents research dedicated to prototyping a panelized building system developed in an academic setting, but not yet deployed in a “real world” context. The “building” in this system is fabricated using waste cardboard in combination with common repurposed wood. The system is conceptualized for use within low-income urban populations living in developing countries who cannot afford to build using conventional masonry or concrete-based approaches; and specifically, for populations who have easy access to waste cardboard and other discarded materials. The research presented here includes the design concept and production workflow for a panelized waste cardboard-based building system. The workflow includes the material collection and documentation, building parts design, building parts fabrication, and building parts assembly. The main component of this building system is a load-bearing wall panel that employs rolled cardboard tubes and plywood framing. In presenting this work, we articulate and illustrate the design criteria for the building components and share the results of construction experimentation using sheets of waste cardboard collected from our university waste stream. The experimentation concludes with the assembly of a full-scale sectional house prototype.

**ANALYSIS OF SCIENTIFIC PRODUCTION IN THE SCOPE OF THE
BRAZILIAN NATIONAL NETWORK FOR RESEARCH AND
DEVELOPMENT OF BAMBU - REDEBAMBU/BR: BIBLIOMETRY AND
SOCIAL NETWORKS**

Ohayon, Pierre¹; Ghavami, Khosrow²; Siqueira, Cristiana³; Lopes, Sara³

¹ Departamento de Contabilidade/ Faculdade de Administração e Ciências Contábeis/Universidade Federal do Rio de Janeiro - FACC/UFRJ, Brazil

² Departamento de Engenharia Civil/ Pontifícia Universidade Católica do Rio de Janeiro (CIV/PUC-Rio), Brazil

³ Departamento de Biblioteconomia e Gestão de Unidades de Informação / Faculdade de Administração e Ciências Contábeis/Universidade Federal do Rio de Janeiro - FACC/UFRJ, Brazil

ABSTRACT

Through the Call for Projects MCTIC/TRANSVERSAL ACTION/CNPq n°. 66/2013, the Brazilian Ministry of Science, Technology, Innovation and Communications (MCTIC) created Redebambu/BR within the PNMCB - National Policy for Incentive to the Management and Planting of Bamboo. The study aims to verify, among the projects granted, those related to bamboo's theme, their scientific production in the last five years of its six projects coordinators, through bibliometric analysis and social networks. This exploratory study is based on specialized literature and documents retrieved from the *Lattes Curricula* of the six sponsored project coordinators. It presents the current panorama of the scientific production of the network, composed of a total of 88 researchers and shows the fields of application of bibliometrics within Redebambu/BR. Irregular distribution of researchers and scientific production is observed in the country. Finally, it is recommended: good use of bibliometrics; greater focus on users' information needs for projects and programs; establishment and maintenance of a verifiable and relevant public database; closer integration of planning and evaluation to decision making.

Keywords: Project, RedeBambu/BR, Scientific production, Bibliometric indicators, Social networks.

BIBLIOMETRIC ANALYSIS OF SCIENTIFIC AND TECHNICAL PAPERS WITHIN NOCMAT 1984-2017 INTERNATIONAL CONFERENCES

**Ohayon, Pierre¹; Sharafi Rad, Ali²; Ghavami, Khosrow³; Siqueira, Cristiana⁴;
Lopes, Sara⁴**

¹ Departamento de Contabilidade/ Faculdade de Administração e Ciências Contábeis/Universidade Federal do Rio de Janeiro - FACC/UFRJ, Brazil;

² Departamento de Engenharia Industrial/ Pontifícia Universidade Católica do Rio de Janeiro (DEI/PUC-Rio), Brazil;

³ Departamento de Engenharia Civil/ Pontifícia Universidade Católica do Rio de Janeiro (CIV/PUC-Rio), Brazil;

⁴ Departamento de Biblioteconomia e Gestão de Unidades de Informação / Faculdade de Administração e Ciências Contábeis/Universidade Federal do Rio de Janeiro - FACC/UFRJ, Brazil;

ABSTRACT

The last International Conference on Non-Conventional Materials and Technologies (NOCMAT) held in Mexico in 2017 presented more than 80 new papers among different NOCMAT themes, showing that there is a great number of scientific and technical studies being developed. 1,485 articles have been presented along the 16 International Conferences, since the first one held in Brazil, in 1984. The series of NOCMAT Conferences have proven to be a leading forum where scholars, governmental and non-governmental agencies, practitioners exchange innovations of low energy cement technologies, new ecological materials and systems such as bamboo and natural fibers. To show the reliability and durability of the newly developed materials and technologies, in addition to the results obtained in the laboratories, large scale constructions should be built and permanently monitored, requiring higher and continued investments from sponsoring agencies and private organizations. The general objective of this study is to analyze the betweenness of researches presented within all the thematic areas of the NOCMAT Conferences. It presents a bibliometric analysis of the network created, mapping the actors (nodes) and its relations (edges) by participating authors, involved Institutions; participating Countries and Year, and NOCMAT Themes, along the last 33 years.

Keywords: NOCMAT Thematic Trends, International Conferences, Papers, Bibliometric Analysis.

**ANALYZING FIVE EVALUATION APPROACHES FOR R&D PROJECTS
WITHIN THE BRAZILIAN NATIONAL BAMBOO'S NETWORK –
REDEBAMBU/BR**

Pierre Ohayon¹, Khosrow Ghavami²

¹ Universidade Federal do Rio de Janeiro – UFRJ, Brazil;

² Pontifícia Universidade Católica do Rio de Janeiro – PUC-Rio, Brazil;

ABSTRACT

The Brazilian Ministry of Science, Technology, Innovations and Communications (MCTIC) and its National Council for Scientific and Technological Development (CNPq) launched the call for research and development projects nº 66/2013 to select proposals for financial support able to contribute significantly for the scientific and technological development and innovation in the country, specifically for structuring the National Network for Research and Development of Bamboo namely called Redebambu/BR. The Redebambu/BR network supports the implementation of PNMCB - National Policy to Encourage Handling, Sustainable Planting and Preservation of Bamboo which has been created by the Law 12.484/2011. In the context of sustainable development, there is a need for a general framework of analysis from impacts to economic and social improvements to understand innovation process and for a greater coordination of research efforts. Systematic evaluation issues are becoming of increased concern notably for state support agencies for sponsored R&D programs and projects. This qualitative study presents and analyzes five important evaluation approaches responding to policy needs for Redebambu/BR network and its NOCMAT – *non-conventional materials and technologies* sponsored projects, specifically: (1) Impact evaluation; (2) Implementation evaluation; (3) Goalfree evaluation; (4) Process evaluation; and (5) Pluralist evaluation. A number of strengths and weaknesses of each approach is highlighted. Finally, questions regarding the adequate evaluation objectives, the appropriate report's content and the effective way for evaluation results meet real users needs are considered and discussed.

Keywords: NOCMAT Projects, Evaluation approaches, Network, Redebambu/Br

DESIGNING & BUILDING WITH BAMBOO



EXPERIMENTS WITH PARTS OF RINGS TO DETERMINE THE INNER AND OUTER CIRCUNFERENTIAL STRENGTH OF BAMBOO

Richard Morán¹, Silvia Greco², Cliff Konrath², Luisa Molari², Jose J. Garcia¹

¹ Escuela de Ingeniería Civil y Geomática, Universidad del Valle, Cali, Colombia;

² DICAM, Alma Mater Studiorum, University of Bologna, Bologna, Italy;

ABSTRACT

Bamboo is a natural sustainable material with a high potential to substitute high contaminating construction materials in various applications. It is a heterogeneous material axially reinforced with cellulose fibers that confers high axial mechanical properties. However, it is prone to longitudinal fissures, mainly due to tensile and shear stress components. Previous studies have been focused on determining the circumferential strength of bamboo using the edge bearing tests. To complement these efforts, two tests with parts of rings are proposed to determine the inner and outer circumferential tensile strength of bamboo. In the first set-up, a semi-ring is radially loaded at the middle section and supported on rollers at both ends such that the inner surface of the specimen is under tensile stress. In the second protocol, similar to the edge bearing test for a complete ring, a specimen bigger than a semi-ring is submitted to compression loading to generate tensile circumferential stresses on the outer surface. Both tests are compression based. The ongoing experimental program includes the bamboo species *Guadua angustifolia*, *Phyllostachys edulis*, *Bambusoides*, *Vivax*, *Iridescens* and *Violascens*. The inner failure strain was significantly higher than the outer for all the species. A brittle failure was observed with longitudinal fissures initiated at the tensile surface. Stress determination through the wall thickness is highly dependent on the constitutive equation. Taking into account the variation of the circumferential modulus with a radial position, the outer strength for the bamboo species *Guadua angustifolia* was 10.0 MPa (COV=0.09, n = 15), which is about 50% higher than the inner strength of 6.4 MPa (COV=0.26, n =15). Higher failure stresses were obtained for the European species calculated with a homogeneous model. More experiments have to be conducted to analyze the variation with radius of the circumferential modulus of the European species for a more accurate determination of strength.



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

ANALYSIS OF BOND-BEHAVIOR OF BAMBOO STRIP AND BAMBOO BIO-CONCRETE

Nathalia Andrade da Silva¹, Bruno Menezes da Cunha Gomes¹, Vanessa Maria Andreola¹, M'hamed Yassin Rajiv da Gloria¹, Romildo Dias Toledo Filho¹

¹ Department of Civil Engineering, COPPE, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil.

ABSTRACT

Bamboo presents great potential due to its mechanical properties, ease of planting and CO_2 capture. However, for its use as structural reinforcement in the form of strips, it is necessary to know its bond-behavior with the cementitious matrix. The present article aims to study the bond-behavior between bamboo strips and different bamboo bio-concretes. Bio-concretes containing volumetric fractions of 25, 35 and 45% of bamboo particles were used in cementitious matrices. The bamboo strips were submitted to three treatments: epoxy resin, epoxy with coarse sand, and epoxy resin with fine sand. The effect of these treatments on the bond-behavior was determined through pullout tests. The results indicated that the treatment of epoxy resin with the sands presented a more satisfactory result, requiring a force of 9 kN for the pulling out and resulting in a bond tensions of 4.5 MPa.



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

FULL-CULM BAMBOO AS A FULL-FLEDGED ENGINEERING MATERIAL

**Kent A. Harries¹, Ian Nettleship¹, Yusuf Akinbade¹, Christopher Papadopoulos²,
Felipe Acosta², Johanna Morales Albino², and Mairim Ariezaga Gonzalez²**

¹ University of Pittsburgh, USA;

² University of Puerto Rico-Mayaguez, USA;

ABSTRACT

This paper provides an overview of the activities of a US National Science Foundation (NSF) funded project Full-Culm Bamboo as a Full-Fledged Engineering Material (Project Numbers NSF CMMI 1634739 and 1634828). The project, funded in 2017, is a collaboration between teams at the Universities of Pittsburgh and Puerto Rico Mayaguez.

Keywords: bamboo, geometric properties, material properties, modelling, uncertainty



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

SCREW WITHDRAWAL CAPACITY IN FULL-CULM BAMBOO

Phoebe Morrill¹, Chase Rogers¹, Chelsea Flower¹, Yusuf Akinbade¹, Kent A. Harries¹

¹ University of Pittsburgh, USA;

ABSTRACT

The use of screw connections in full-culm bamboo is often assumed to be limited, primarily due to the propensity for splitting of the culm. This study demonstrates that small diameter screws can be used effectively in full-culm bamboo. The study explores the withdrawal capacity of candidate screw types in order to identify those that may be used to achieve a high capacity while mitigating splitting failures. Twelve screw types of three standard sizes, ranging from hardwood screws, self-tapping wood screws and concrete anchors, are tested in conditions of both pre-drilled and self-tapping installation procedures. All tests are conducted on samples of *P. edulis* (Moso) having culm wall thickness on the order of 7 mm. The results of this study are intended to inform the applications for which screw connection to bamboo are viable.

Keywords: bamboo, bamboo connections, screws

NON-CONVENTIONAL MATERIALS / TECHNOLOGIES & RESILIENCE



RWANDA INSTITUTE FOR CONSERVATION AGRICULTURE: LESSONS LEARNT DESIGNING EARTH WALLS TO CODE IN A MODERATE SEISMIC ZONE

**Rosie Goldrick¹, James Kitchin², Aimable Mukire³, Will Arnold⁴, Jorge Lopez⁵,
Tim White⁶**

¹ Engineering Director, MASS Design Group, Rwanda;

² Associate Engineer, MASS Design Group, Rwanda;

³ Graduate Engineer, MASS Design Group, Rwanda;

⁴ Senior Engineer, Arup, UK, seconded to MASS Design Group, Rwanda;

⁵ Senior Engineer, Arup International Development, UK;

⁶ Senior Consultant, Arup International Development, UK;

ABSTRACT

Due to open in September 2019, the Rwanda Institute for Conservation Agriculture will be a new 20,000m² institution in the Eastern province of Rwanda that will prepare future entrepreneurs with the technical and practical skills to create solutions for more sustainable food production in Rwanda. With 80% of the country's population relying on agriculture for their livelihood, yet 20% of the population being food insecure, there is a pressing need to promote more sustainable agricultural techniques. The campus design brief therefore demanded a high-quality institute that would push the boundaries of sustainable design. Consisting of buildings up to two storeys and having determined the site soil to be suitable for construction, the walls are built almost entirely from site produced reinforced earth blocks and reinforced rammed earth. Funded by the Howard G. Buffett Foundation and designed in collaboration by MASS Design Group and Arup, the team made reference to both Eurocodes and New Zealand Standards to ensure that the structures would resist the moderate seismicity present in Rwanda, whilst also aiming to minimise embodied carbon from the use of cement and steel reinforcement. The paper describes the project design process, highlighting the limitations of the codes and the challenges faced by engineers wishing to design sustainable, affordable, and buildable earth structures in moderate seismic zones. The paper concludes by suggesting areas for further work.

Keywords: Earth, CSEB, Rammed Earth, Seismic, Code

ANALYSIS OF EARTHQUAKE TESTING TRENDS OF ALTERNATIVE BUILDING MATERIALS

Elisabeth Vitswamba¹

¹Engineering for Change;

ABSTRACT

In a world that is experiencing rapid population growth, an increase in precarious building, and increase in the effects of climate change, promoting the use of alternative, sustainable building materials is a way to positively impact communities by providing affordable housing with materials that have a smaller carbon footprint. One challenge in the effort to make alternative building materials accepted and adopted by investors, designers, builders, and households, is the education needed to build well with the materials, and the need to have these methods accepted by governments and included in local building codes. An extra challenge exists in seismic regions where buildings must be designed to sustain additional forces. Several countries have seen extreme damage and loss of life due to earthquakes including Pakistan, Haiti, Nepal, and Chile. Designers and implementers of alternative building materials often do not have expertise in earthquake design, a complex area of study. However, even a basic knowledge of what is being done in earthquake design and testing, and where the bar has been set by way of testing of alternative building assemblies, can provide clearer direction to next steps in developing appropriate details using these materials, and provide the proof that these materials can be resilient to seismic forces to push for inclusion in local standards. An example of one such development is the work of Good Earth Global that have worked closely with the government of Nepal and have advocated for earthbag designs to be included in the local building code. The paper reviews existing literature to summarize the many trends in earthquake testing, determine the status of testing of specific alternative building materials, and based on the findings highlight where gaps may exist and what next steps may be taken in an effort to give additional credibility in the seismic resistance of alternative building assemblies.

Keywords: seismic resistance, earthquake simulation, earthquake testing, alternative building materials

SOCIAL HOUSING ON EARTH AND BIOENVIRONMENTAL RESILIENCE: TWO CASES IN TUCUMÁN, ARGENTINA

Matías Ortega¹, Beatriz Garzón¹

¹ San Miguel de Tucumán, Tucumán, Argentine;

ABSTRACT

Resilience as a concept in architecture is relatively new, and it responds to the dizzying era of changes that characterizes the contemporary world. The objective of any sustainable development agenda seeks to minimize the anthropogenic impact of the prevailing development model, responding to a cultural transition and paradigms. In this context, it is seen the flourishing of sustainable architecture, comprehensive search of architectural objects with multidimensional references to environmental issues: materials of construction, bioclimatic design, collaborative ways of execution, included technologies, maintenance, etc. This work aims to get to know the experience of two houses generated in the implementation of a program of social housing that, in coordination with a local community, resorted to adobe for the materialization of the walls, serving to a technological syncretism. It is concluded that these contribute to the resilience in the province of Tucumán and the paradigm of sustainable development.

Keywords: resilience, sustainable development, technology, building materials, adobe

CONCRETE & CEMENTITIOUS MATERIALS



EFFECTS OF SAWDUST ADDITION AND PARTIAL REPLACEMENT OF CEMENT WITH CARBIDE WASTE ON STRENGTH AND SORPTION PROPERTIES OF HOLLOW CONCRETE BLOCKS

Abel O. Olorunnisola¹, Oludele O. Oladejo¹

¹ Department of Wood Products Engineering, University of Ibadan, Ibadan, Nigeria

ABSTRACT

Housing shortage in Nigeria due to rising price of construction materials makes it logical to consider alternative building materials. Concrete blocks are generally used for building constructions in West Africa. Paradoxically, many African countries are grappling with the challenges of waste management, when some of the so called waste materials could be incorporated into building materials. The aim of this study was to investigate the possibility of incorporating sawdust and welder's carbide waste in the mix for the production of hollow concrete blocks. Representative samples of 100 x 100 x 100 mm Sawdust-Reinforced Concrete Blocks (SRCB) were produced using different percentages of Teak (*Tectona grandis*) sawdust (20%, 25%, 30%) and carbide waste (30%, 25%, 20%) in the mix. These were cured for 28 days, after which compressive strength, 24- hour Water Absorption (WA) and Thickness Swelling (TS) were determined. The mean compressive strength values ranged from 0.32 to 0.75 N/mm². The maximum compressive strength which was obtained in the SRCB mix containing 20% sawdust and partial replacement of Portland cement by up to 30% of carbide waste fell within the measured strength values (0.5 - 1 N/mm²) reported for commercially produced hollow concrete blocks in Nigeria. The WA (6.1 - 10.3%) and TS (1.2 - 1.9%) were quite acceptable. The preliminary cost analysis indicated the possibility of a 20% reduction in the production of the concrete blocks with the incorporation of sawdust and carbide waste in the production mix.

Keywords: Concrete blocks, Sawdust, Carbide waste, Building materials

SELF-COMPACTING CONCRETES USING CALCIUM-RICH ASHES AS ALTERNATIVE FILLERS

**Rodrigo Araújo Pereira Lima¹, Erika Pinto Marinho¹, Ana Cecilia Vieira da
Nóbrega¹**

¹ Postgraduate Program in Civil and Environmental Engineering, Agreste Academic Center, Federal
University of Pernambuco, PE, BR;

ABSTRACT

Algaroba wood is a usual energy source used in laundry-boilers in the Local Productive Arrangement (LPA) of Clothes, Pernambuco – Brazil. However, these algaroba wood ashes are constituted primarily by calcium carbonate (CaCO_3), which can act as an alternative filler. The limestone fillers are widely used as fines in self-compacting concretes (SCC), being a natural resource that can be extinguished in the future. In order to verify the feasibility of the incorporation of the algaroba ashes in the SCC, self-compacting concretes (SCC) were evaluated with partial (0, 25, 50, 75%) and total replacement of the conventional limestone by the alternative filler. Cohesion, fluidity, and resistance to segregation tests were carried out according to the Brazilian Standards. Also, other fresh and hardened SCC properties were analyzed. The mixes were optimized using raw-materials compactness experimentally measured. With this research, it was possible to confirm that the algaroba wood ash is a viable material for incorporation in the SCC up to 50% (by cement weight), keeping the self-compactness ability, as well as providing compressive resistance gains in the early ages.

EFFECTS OF TEMPERATURE IN SELF-COMPACTING CONCRETES USING CALCIUM-RICH ASHES AS ALTERNATIVE FILLERS

Jonatércio Florêncio de Vasconcelos Marinho¹, Erika Pinto Marinho¹, Ana Cecilia Vieira da Nóbrega¹

¹ Postgraduate Program in Civil and Environmental Engineering, Agreste Academic Center, Federal University of Pernambuco, PE, BR;

ABSTRACT

The use of wood as an energy matrix still prevails in industrial scenarios, generating by-products. The ashes sometimes are discarded in nature without an adequate destination. Algaroba trees are in the northeast part of Brazil, India and other places. Algaroba tree ashes are rich in calcium carbonate (CaCO_3) and can be applied instead of limestone. Limestone fillers are commonly used as fines in cementitious materials. The use of fines is essential to ensure the maintenance of the fresh-state behavior in self-compacting concretes (SCC). Also, mixing and casting concrete in hot climates (for example, in tropical regions) can affect the fresh state conditions, due to the evaporation of the mixing water. Self-compacting concretes are even more susceptible due to their high-water demand. Thus, the present research aimed to analyze the properties in the fresh and hardened state of self-compacting concretes made incorporating the algaroba trees ashes produced in hot weather conditions. For this, an optimized compact granular skeleton was developed based on the constituent materials. The raw-materials were preheated simulating a hot climate region. The use of algaroba ashes improved the compressive strength and decreased the permeability of the SCC, especially in hot weather conditions. To sum up, this material can be an excellent alternative to replace the calcareous filler for SCC production.

FROM PRESCRIPTIVE TO PERFORMANCE BASED DURABILITY DESIGN AND SPECIFICATION OF CONCRETE STRUCTURES

Mike Otieno¹

¹ School of Civil and Environmental Engineering University of the Witwatersrand, Johannesburg

ABSTRACT

Africa is experiencing an increased growth in infrastructural development, with concrete being the most commonly used construction material. Concrete structures deteriorate with time at a rate dependent on both the quality of the concrete and the aggressivity of the exposure environment. A lot of evidence is available in the literature of premature deterioration (and durability failure) of concrete structures due to, for example, steel corrosion. It is therefore important that engineers are acutely aware of the need to incorporate durability design and specification in their day to day design process; focus should not only be placed on structural strength and stability. This paper presents fundamental concepts of durability design and specification of concrete. Two approaches prescriptive and performance-based are discussed. In general, prescriptive approaches present a number of deficiencies which can be overcome by using performance-based approaches. In Africa, South Africa has been on the forefront in developing and implementing performance-based durability design and specification using the durability index (DI) tests. The DI tests are simple and relatively inexpensive and have been briefly presented in this paper with the intention of encouraging other African countries to adopt the tests for durability design and specification. This paper puts forward a case for the need to consistently incorporate durability in the design and construction stages in order to ensure that RC structures meet their design life. This is important for Africa if the infrastructural developments are to be worthwhile in the long-term. In order to implement concrete durability design and specification, civil engineering scholars in tertiary institutions and practicing engineers need adequate knowledge of concrete as a construction material.

Keywords: Concrete, Durability, Prescriptive, Performance-based, Service life prediction.

ASSESSMENT OF THE EVOLUTION OF THE COMPRESSIVE STRENGTH OF STRUCTURAL CONCRETE WITH RECYCLED COARSE AGGREGATES AND RICE HUSK ASH

**Camila Lacerda Gomesa¹, Jerônimo Coura-Sobrinho¹, Conrado de Souza
Rodrigues¹, Flávia Spitale Jacques Poggiali¹**

¹ Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG), Brazil;

ABSTRACT

Concrete production is one of the activities that most emits pollutants in the atmosphere. The demolition of existing structures is also a major environmental problem, because it generates waste that needs appropriate disposal. Industrial and agricultural waste can be used in concrete production, reducing the use of cement and eliminating the need for disposal sites. From these considerations, it is possible to perceive the importance of studying the use of such materials in the production of concrete. The objective of this paper is to assess the evolution of compressive strength of concrete made from recycled aggregates (RA), produced from construction and demolition waste (CDW), and with rice husk ash (RHA) as a partial replacement for cement. For the accomplishment of the study, the characterization of the aggregates and the RHA is carried out in order to assess its properties, composition and pozzolanic activity. For this study, concrete mixtures were produced in two stages. In the first stage, concrete was produced with total substitution of the coarse aggregate by CDW and compressive strength tests were performed at 7 and 28 days. In the second stage, besides the substitution of natural aggregates (NA), the cement was replaced by RHA in 10% and 15% and the compression assays were performed at 7, 28 and 91 days, in order to assess the resistance gain over time. The mixture containing 15% of RHA presented the highest resistance gain over time, obtaining an increase of 34% from 7 to 91 days, while the mixture with 10% of RHA obtained an increase of 18%.

COMPARATIVE STUDY BETWEEN PROPERTIES OF GEOPOLYMERIC CEMENTS PRODUCED WITH DIFFERENT TYPES OF METAKAOLIN

Paloma Santos Xavier de Alcantara¹, Normando Perazzo Barbosa², Primo Fernandes Filho², Letícia Cândido Mariz³, Maria Laiz de Fátima Cabral Pontes⁴

¹ PhD Student, Federal University of Paraíba, João Pessoa, Brazil;

² Prof. Center of Technology of Federal University of Paraíba, João Pessoa, Brazil;

³ Undergraduate Civil Engineering Student, Faculty of Maurício de Nassau, João Pessoa, Brazil;

⁴ Master Degree Student, Program on Science and Materials Engineering, Federal University of Paraíba;

ABSTRACT

Geopolymers are produced by the alkaline activation of aluminosilicates. They have cementitious properties, excellent durability and dimensional stability. There are several applications on industry: fire-resistant composites, low-CO₂ concrete, waste incorporation and metal encapsulation. One of the most used aluminosilicates (precursor material) for the production of geopolymers is metakaolin (MK). This research aims to compare properties of geopolymer cements produced with two different commercial MKs (metakaolin 1 - MK1 and metakaolin 2 – MK2). Alkaline activator solution was based on sodium hydroxide (NaOH) and sodium silicate (Na₂OSiO₃). Precursors were physically characterized by Blaine fineness, specific mass, as well as chemically and microstructurally through modified Chapelle, X-ray fluorescence (XRF) and X-ray diffraction (XRD). Property tested on pastes on fresh state was setting time through the Vicat apparatus. For the hardened state, compressive strength was tested. The analyzed metakaolins have different chemical reactivities. Compressive strength of the geopolymer cements produced with MK2 were 98.9% higher than those produced with MK1. Setting times presented big differences, of the order of hours. Thus, it can be stated that the properties of geopolymer cements are significantly altered when using different MKs.

THE INFLUENCE OF WOOD SHAVINGS TREATMENTS ON THEIR COMPATIBILITY WITH CEMENTITIOUS MATRIX

Mônica Cristina Pinto¹, M'hamed Yassin Rajiv da Gloria¹, Romildo Dias Toledo Filho¹

¹ Department of Civil Engineering, COPPE, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil;

ABSTRACT

This work aimed to study the effect of different wood shavings treatments on the removal of extractives for a better chemical compatibility with the cementitious matrix. The compatibility was accessed through determination of setting time of the matrix by the Vicat test. First of all, the wood shavings were immersed in water at temperatures of 25 °C, 60 °C, 80 °C, 85 °C, 90 °C, and 95 °C, respecting the wood to water ratio (w_d/w) of 1/10, by weight. Three immersion times for the lower temperatures were used: 2 hours, 24 hours and 48 hours for 25 °C; 0.5 hour, 1 hour and 2 hours for both 60 °C and 80 °C. An immersion of 0.5 hour was used for the remaining temperatures. Then, cementitious pastes were fabricated with the residual waters and the setting time was determined by Vicat apparatus. The results showed that washing the particles in water at 80 °C for 0.5 hour gave results closed to those for either greater temperatures or greater immersion times. Then, 80 °C / 0.5 hour were chose to test w_d/w equal to 1/5 and 1/4. The subsequent results prove that the water is capable of solubilize more extractives, so it is possible to immerse more wood shavings in the less quantity of water.

BAMBOO REINFORCED CONCRETE: LESSON LEARNED, PROHIBITIONS AND OPPORTUNITIES

**Kent A. Harries¹, Hector Archila², David Trujillo³, Sebastian Kaminski⁴, Edwin
Zea Escamilla⁵**

¹ University of Pittsburgh, USA;

² University of Bath, UK;

³ Coventry University, UK;

⁴ Arup, London, UK;

⁵ CCRS University of Zurich, Switzerland;

ABSTRACT

The use of small diameter whole-culm (bars) and/or split bamboo (a.k.a. splints or strips) has often been proposed as an alternative to reinforcing steel in reinforced concrete. The motivation for such replacement is typically cost and the drive to find more sustainable alternatives in the construction industry. Although bamboo is a material with extraordinary mechanical properties, this paper will summarise the reasons that for most load-bearing applications, bamboo-reinforced concrete is an ill-considered concept: having significant durability, strength and stiffness issues. Additionally, it is argued that bamboo-reinforced concrete does not possess the environmentally friendly credentials often attributed to it. Finally, the authors identify applications in which bamboo reinforcement may prove an acceptable alternative to steel provided durability concerns can be addressed.

Keywords: bamboo, bamboo reinforcement, bamboo-reinforced concrete, durability, life cycle assessment



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

INFLUENCE OF PORCELAIN TILE POLISHING RESIDUES AS A SUPPLEMENTARY CEMENTITIOUS MATERIAL IN CONCRETE

**Humberto Mycael Mota Santos¹, Erika Pinto Marinho¹, Ana Cecília Vieira da
Nóbrega¹**

¹ Postgraduate Program in Civil and Environmental Engineering, Agreste Academic Center, Federal
University of Pernambuco, PE, BR;

ABSTRACT

Porcelain tile polishing residues (PPR) are generally generated in the porcelain tile production process, where much of it is disposed of in landfills. This paper aims to produce sustainable concrete partially replacing Portland cement by these residues, as supplementary cementitious material (0-50%, by cement weight). The properties of the concrete in the fresh and hardened state, including some indicators of durability, were analyzed to 30 MPa concretes. They are dosed using the absolute volume method by the American Concrete Institute (ACI), adapted by the Brazilian Portland Cement Association (ABCP), using a water consumption of 195 l/m³ to obtain an initial 40-60 mm. Also, the cement consumption was kept constant for all the mixtures, to evaluate the real interference of the PPR. As more cement content was replaced, the slump dropped, but it could be attenuated with the use of superplasticizer. The replacement of cement by PPR up to 40% presented a viable solution for both sustainability and the development of more resistant and durable concrete structures.

SOCIAL, ECONOMIC & CULTURAL DIMENSIONS



AFFORDABILITY AND SUSTAINABILITY OF NON-CONVECTIONAL CONSTRUCTION MATERIALS IN KENYA

Joseph Mwiti Marangua¹, Raine Isaksson², Wachira J. Muthengia³, Thiong'o J. Karanja⁴ and John M. Kinuthia⁵

¹ Department of Physical Sciences, Meru University of & Technology, Meru – Kenya;

² Department of Engineering Sciences, Uppsala University, Uppsala – Sweden;

³ Department of Physical Sciences, University of Embu, Embu- Kenya;

⁴ Department of Chemistry, Kenyatta University, Nairobi- Kenya;

⁵ University of South Wales, Pontypridd- United Kingdom;

ABSTRACT

Globally, there is growing demand for low cost, ecologically friendly and technologically suitable construction materials. This is driven by the need for sustainable building materials that could be defined as affordable and with low carbon footprint. Housing plays an important role within sustainable development agenda. Affordable housing is therefore a key priority in most developing countries. Non-convectional construction materials are emerging as a viable option for low cost and eco-friendly materials in Kenya. Kenya is endowed with vast deposits of diversified natural resources, from which different kinds of non-convectional construction materials can be produced. Therefore, there is need for research that focuses on development, application and management of these materials. Materials such as, sugar cane baggasse, rice husks, pineapple wastes, banana stalks, sorghum stalk, bamboo, fired bricks, elephant grass, wheat straw ashes, lime, soil and clay among others are potential non-convectional materials for construction applications. The study aimed at identification and of selected non-convectional materials in Kenya. The potential materials were qualitatively discussed in terms of availability, usability, acceptability of the material and the service life of the expected structures. The most frequently mentioned non-conventional materials available in Kenya were identified and reviewed based on the defined criteria with the purpose to establish a shortlist for the most promising materials. These were studied in more detail resulting in an assessment highlighting opportunities and challenges for building sustainability. Preliminary results indicated that traditional building materials could be sustainable while having a low level for acceptability.

Keywords: Affordable; Eco-friendly; Low carbon footprint; Non-convectional; Sustainable materials; Wastes



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

APPLICATION OF ALTERNATE CONSTRUCTION TECHNIQUES IN REHABILITATION OF URBAN SLUMS

Sridevi Changali¹, Rosie Paul², Shubha B. A.³

¹ Co-Founder & Principal Architect, Masons Ink, Bengaluru, India;

² Co-Founder & Principal Architect, Masons Ink, Bengaluru, India;

³ Senior Architect, Masons Ink, Bengaluru, India;

ABSTRACT

Approximately 62 million people inhabit slums in India today. The living conditions and overall standard of construction is appalling. This paper aims at looking at this larger issue and scope out how alternate building materials and techniques could create a positive impact and become a change maker in building construction. This would be done through case studies of 2 urban in-situ in 2 slums located in Bengaluru, India designed and executed by the authors. The 2 selected case studies were successfully completed in November 2017 using 2 differing wall materials – fly ash bricks and Compressed Stabilized Earth Blocks. The roof employed a filler slab technique that reused the existing clay tiles from the older unit. The tools used to measure the impact would include – post occupancy surveys, thermal comfort, study of costs of construction and tools to analyze these projects against the four pillars of sustainability.

Keywords: Mud Construction, Alternate building materials, Impact assessments.

A STUDY OF THE SOCIO-ECONOMIC CULTURAL AND ENVIRONMENTAL IMPACT OF THE USE OF UNCONVENTIONAL BUILDING MATERIALS IN CONVENTIONAL BUILDING TYPOLOGIES

Rosie Paul¹, Sridevi Changali²

¹ Co-Founder & Principal Architect, Masons Ink, Bengaluru, India;

² Co-Founder & Principal Architect, Masons Ink, Bengaluru, India;

ABSTRACT

India is one of the fastest growing economies in the world. Subsequently, the size of the construction industry alone is projected to be 1 trillion USD by the year 2025 thus emphasizing the need for the use of alternate techniques in construction that are sustainable as well as cost effective. This paper aims to emphasize the benefits of using non-conventional materials with a special focus on earthen construction and other alternate construction techniques through a wider range of building typologies, thus showcasing its versatility. This will be done through case studies of buildings designed and executed by the authors ranging from farm houses to vocational training centers to Low Income housing. These projects will be analysed along the four pillars of sustainability namely – the environmental, the cultural, the social and economic impacts that the unique construction techniques and the construction processes have brought about. The techniques employed in these constructions ranges from Compressed Stabilized earth blocks, Rammed Earth, Nubian Vaults, Filler slabs, Traditional clay roofs etc. The different building typologies will be analyzed against a framework or matrix which highlight the positive impact these techniques have in the context of holistic sustainability.

Keywords: Mud Construction, Alternate building materials, Impact Assessments

**USE OF NON-CONVENTIONAL MATERIAL IN THE BUILDINGS OF THE
ITAMARATI FARM, BEFORE AND AFTER THE ADAPTATIONS TO THE
MODEL OF RURAL SETTLEMENTS MANAGED BY INCRA.**

Gisele Santos Estrella¹, Marney Pascoli Cereda¹, Luca Estrella Medeiros², Milene Santos Estrella¹

¹ Dom Bosco Catholic University, Brazil;

² Anhanguera Uniderp University, Brazil,

ABSTRACT

The article compares the use of unconventional materials used in the remaining buildings of Itamarati Farm, in the municipality of Ponta Porã, state of South Mato Grosso, before and after assimilation of the property and adaptation for use in agrarian reform. The methodology consisted of visits and photographic records of the remaining buildings of the old farm, and of the new buildings, which are now part of the New Itamarati District. Interviews were conducted with officials of the involved and technical bodies, meetings with settled families. The theoretical reference was based on articles, books, historical documents. The analysis of the materials used in the area corresponding to the Itamarati Farm, later bought and occupied by the Agrarian reform National Institute (INCRA) as a federal settlement, showed, as expected, that all the buildings of the period were built with conventional material. Even the wood found in the employees' homes and in the church, which was little altered by occupation. However, in the same area, buildings of commercial and social use, housing and complementary buildings were identified, with an estimated result of 35% regarding the use of non conventional material. These buildings were erected or adapted in invasions that occurred at the beginning of the stage Itamarati I, since there was no care to prevent the uncontrolled occupation of the properties available in the purchase process. The survey showed that 85% of the families reused the materials of the houses and shacks during the improvements and annexes in their dwellings. Other unconventional material identified was cut eucalyptus in areas of encouraged planting, mainly used as pillars and beams. In the area of the New Itamarati District, there are still some non-inhabited buildings, built in haste by the inhabitants of the beginning of the occupation, who used eucalyptus shells for closing the walls and making doors and windows, classified with 50 to 65% unconventional.

Keywords: Non conventional materials, Agrarian reform, Rural buildings, Rural settlement.

INFLUENCE FACTORS AFFECTING THE ADOPTION OF NON CONVENTIONAL MATERIALS IN THE RURAL DWELLINGS, SOUTH MATO GROSSO, BRAZIL

Gisele Santos Estrella¹, Milene Santos Estrella¹, Luca Estrella Medeiros²

¹ Dom Bosco Catholic University, Brazil;

² Anhanguera Uniderp University, Brazil,

ABSTRACT

Although the use of non-conventional building materials is encouraged for several reasons, including environmental and so on, their use is still incipient. The research analyzes the factors that influence the decision on the use of nonconventional material (MNC) in rural areas, based on the Itamarati I and II settlements, in the municipality of Ponta Porã, Mato Grosso do Sul, managed by the National Institute of Colonization and Agrarian Reform (INCRA). In the construction model adopted after the occupation of the lot, the settler receives a minimum plant that will have to execute on a joint effort basis, while the purchase of the material is made by INCRA. Sampling took into account the variables that could influence this decision, considering as main factor the existence of MNC in the place and the spatiality, which includes the location of the lot. Other variables selected from the literature were technical and social training, on-site dwelling time, the level of technical knowledge about construction, the characteristics of rural construction, involvement with social movements, and previous experience with non-conventional constructive material. The information was complemented with questionnaire applied and interviews with settled families. The quantification of the MNC used in the buildings was made on a visit to the lot on a scale of 0 to 100% for the extremes. The results showed that MNC were poorly present in the main residence, as was expected, where only eucalyptus logs and their processed wood were identified, both as conventional and nonconventional material (closure of walls) due to their planting in an area of the settlements. The distance from the lot in relation to the New District Itamarati, where there are stores of construction material, influenced the percentage of use, but not the other factors evaluated. Also, as expected, the other buildings, for which the residents do not receive INCRA material, presented a higher percentage of MNC, which varied from 35 to 65%. Bamboo, which is an easy-to-apply material, was only identified in complementary buildings (OE) such as chicken and vegetable sheds, as well as reuse material. It is recommended to encourage the planting and use in the rural buildings of eucalyptus and bamboo, in the Public policies of rural dwellings, besides informing the rural settlers about the appropriate use of nonconventional materials, meeting the world technical standards.

Keywords: Non conventional material; rural dwelling; rural settlement.

SOIL BUILDING BLOCKS STABILIZED WITH WHEAT STRAW AND CEMENT

Benhaoua, W.¹, Grine, K.¹, Kenai, S.¹

¹ Geomaterials and civil engineering laboratory, University of Blida1, Algeria;

ABSTRACT

Stabilized earth blocs have been used in many countries as an alternative local construction materials with environmental and economic advantages. However, durability especially under humid environments could hinder their use. Stabilization using cement and natural fibres could enhance their durability and risk of cracking. The present paper deals with a laboratory investigation into the effect of adding a proportion of cement and/or naturel fibres (wheat fibres), on the behaviour of a local silty soil under compression, wetting/drying cycles, shrinkage and upon its aptitude to water absorption (capillary absorption) and thermal conductivity. Unconfined compressive strength (UCS), shrinkage, wetting and drying, capillary absorption and thermal conductivity tests were performed on both, untreated soil samples and soil samples stabilised with cement and/or wheat fibres. The results show that the cement has more effect on increasing the strength, the durability, the thermal conductivity and decreasing the capillary absorption and the shrinkage. However, when mixed with cement, the natural fibres lead to a decrease in the thermal conductivity, an increase in the capillary absorption and to a further reduction in the shrinkage.

Keywords: soil, wheat fibers, cement, durability, thermal conductivity.

THE POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK FOR ADOPTION OF INNOVATIVE BUILDING TECHNOLOGIES IN KENYA

Edwin K. Kaburua¹, Mugwima Njugunab¹, Titus Kivaac¹

¹ Penn State University, University Park, State College, Beaver, Pittsburgh, PA, USA;

ABSTRACT

Innovative building technologies (ibt) are often exhibited as a panacea for mitigating housing delivery shortfalls in the light of the ever growing construction costs. the regulatory framework has however been often cited as a challenge to this probable solution of affordable housing. this paper examines the legal and administrative framework that bears on adoption of ibt in construction industry of kenya. to achieve this, the paper describes the existing legal framework influencing adoption innovative building technologies beginning with a broad perspective of the constitution of kenya in relation to housing as a basic human right. a review of relevant legislations that bear on innovative building technologies reveal some critical handicaps to adoption of ibt. the paper also appreciates considerable policy effort by the government to ease the barriers through the housing policy, proposed construction industry policy and proposed planning and building regulations. The paper relies on desktop study of relevant laws and policies together with relevant reviews on their bearing on ibt adoption. the main conclusion is that the policy and legal framework for innovative building technologies is elaborate but with segments of outdated provisions that serve to inhibit ibt adoption. these include the building code that put emphasis on material composition. this is however addressed in the proposed planning and building regulations which lay emphasis on performance. the administrative framework is liberal and uncoordinated. There is thus need to actualize the elaborate policy provisions through establishment of institutions with specific mandate to implement or oversee implementation of ibt policy provisions.

Keywords: Innovative building technologies, legal framework, housing policy, administrative framework

MATERIALS WITH HIGH DENSITY / THERMAL MASS



CASE STUDY ON SMALL COMPANIES OF ORNAMENTAL STONE PROCESSING IN THE CITY OF MONTEIRO - PARAÍBA – BRAZIL

**Thatiane Amanda da Silva¹, José Augusto Gomes Neto², Iracira José da Costa
Ribeiro¹, Adri Duarte Lucena¹ Normando Perazzo Barbosa²**

¹ Federal Institute of Paraíba, Monteiro, PB, Brazil;

² Federal University of Paraíba, João Pessoa, PB, Brazil;

ABSTRACT

The construction industry generates a large amount of pollutant waste in all constructive steps, this waste when improperly disposed of causes several environmental problems. The ornamental rocks are being used extensively in the buildings for coatings, furniture making and decoration objects. With the growth of this sector, the amount of waste generated increases the impact caused to the environment by the extraction of the raw material and the inadequate disposal of the waste generated. The present work had as objective to investigate the main forms of destination of the residues generated by the companies benefiting rocks in the city and Monteiro – Paraíba – Brazil. The visits were carried out in companies, the research team initially sought to know the main difficulties encountered in waste management through informal conversations with employees and owners, followed by the stages of production and final destination to know the types of waste generated and to analyze the forms of destination and the possible environmental problems generated. In the stages of processing of the rocks, two types of waste are generated: the residual dust and the flakes of stones of different sizes. According to CONAMA 307/2002 these wastes can be classified as class A materials that can be used in construction as aggregates. All wastes are deposited on land or sent to the landfill, causing disfigurement of the landscape, silting of water courses, and respiratory problems for the population. Workshops and lectures were held with city residents and students from the Federal Institute of Education, Science and Technology of Paraíba - Campus Monteiro to share knowledge about the environmental problems caused and to know techniques for reuse of waste. The situation of companies' sector of the beneficiary of ornamental rocks is worrying and requires immediate changes in waste management contributing to the sustainable development of the construction industry avoiding the increase of various environmental problems.

Keywords: Ornamental rocks. Waste. Reuse. Recycling. Sustainability.

**RE-DESIGN PROPOSAL FOR THE THERMAL AND ENERGETIC
EFFICIENCY OF A PRIMARY HEALTH CENTER IN TUCUMÁN,
ARGENTINA.**

Amalita Fernández¹, Silvia Beatriz Garzón²

¹ National University of Tucumán, CONICET, Argentina;

² National University of Tucumán, CONICET, Argentina;

ABSTRACT

The buildings destined to health establishments are among those that require greater consumption of energy for their operation. In Argentina, the "Norms of Organization and Functioning" of the National Quality Assurance Program for Medical Care demand high degrees of acclimatization. This necessity to maintain high environmental and health standards contribute to a greater energy demand; and, therefore, that the need arises to implement measures that generates very important energy savings that, in turn, make it possible to reorient resources towards health prevention and clinical care. This work proposes the architectural redesign for the thermo-energy efficiency of a Primary Health Care Center (CAPS) in the province of Tucumán, Argentina and the verification thereof, according to standards, in order to achieve its bioenvironmental adequacy through architectural and technological provisions that contribute to improve the comfort and health conditions of its users, to achieve the rational use of energy and the care of the environment. A methodological combination was used, through the following methods: case study, descriptive, analytical, deductive and correlational. The actions carried out were: 1) Recognition and geographical characterization of the study area; 2) Definition of bio-environmental guidelines and strategies; 3) Analysis of the prototype: architectural layout, technological and thermo-physical characteristics of the envelope; 4) Re-design proposal for its bioenvironmental adjustment; 5) Energy efficiency labeling. Likewise, the results reached in this respect and the conclusions in relation to the importance of applying and validating these guidelines and strategies in the design and production of new CAPS or in interventions in those already existing are exposed.

**ABSORBENT MATERIALS FOR CLASSROOMS REVERBERATION
CONTROL IN CLASSROOMS OF SAN MIGUEL DE TUCUMÁN.
PARAMETERS DETERMINATION AND COMPARISON.**

Leonardo Paterlini¹, Beatriz Garzón¹

¹ San Miguel de Tucumán, Tucumán, Argentine;

ABSTRACT

This work aims at making proposals of architectural materials for the improvement of reverberation times (RT) in classrooms through a software. The specific objectives were to determine those sustainable and non-sustainable materials that could be used in classrooms for the optimization of the RT in schools. In this work, a methodological combination was used for carrying out different activities and obtaining results. In a first stage, the case study method was used to analyze the acoustics problematic of a school in San Miguel de Tucumán, Tucumán, Argentina. It is a special case because it belongs to the "program of 700 schools", at the national level. Also, we used the exploratory method for studying materials with possibility of including them to improve the acoustic conditions of classrooms. The descriptive method was also used to understand the totality of the buildings, their spaces and different characteristics. These methods involve tools and specific techniques and those that we use particularly to address and develop the subject matter should be mentioned: a) the RT is determined through the ArchRTCcalculator software developed by the team according to the mathematical formula of Sabine. Starting from the evaluation of 4 alternatives of absorbent materials in a particular classroom, a comparison was made to determine which would be the most appropriate for this purpose and that could also be used.



*18th International Conference on
Non-Conventional Materials and Technologies
"Construction Materials & Technologies for Sustainability"
(18th NOCMAT 2019)
24th – 26th July 2019
Nairobi, Kenya*

A BAMBOO DESIGN CONCEPT FOR LOW-INCOME HOUSING IN KENYA

Shahryar Habibi¹, Esther Obonyo², Ali M. Memari³

¹ Visiting Postdoctoral Scholar, ² Associate Professor, ³ Professor

¹²³ Department of Architectural Engineering, The Pennsylvania State University, University Park

ABSTRACT

This paper discusses the development of a design concept for a typical bamboo house, including the layout configuration and the function/aesthetics properties that are important from architectural perspective. Although bamboo has been used as a structural material in buildings, the uptake in Kenya has been minimal. The authors' main objective is to exemplify an approach for using bamboo as a structural material in low-income housing through strategies that respond to context-specific design constraints and socio-cultural needs. This paper presents a review of examples of vernacular architecture and building elements in Kenya. It then highlights the design of a bamboo-structure residential house based on bio-climatic design strategies. As part of further work, the authors will perform a holistic comparison of the different building materials, focusing specifically on how bamboo can address the sustainability-related issues such as: 1) the cost and use of cement-related concerns associated with concrete blocks; 2) the cost and destruction to land associated with the extraction of natural stones; and 3) the land use conflict, particularly with farming, and reliance on wood fuel systems during the production of fired bricks, which contributes to air pollution and deforestation.