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Editorial

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Natural organic materials such as bamboo have a very important and unique role in the effort to alleviate housing and infrastructure problems, particularly in developing countries. Their use is of a special relevance in the context of widespread damage and destruction caused by natural disasters owing to global warming, which in part attributed to the vast use of polluting and high-energy-demanding materials, such as steel and cement. The application of NOCMAT (Non-Conventional Materials and Technologies) is an urgent need to protect the environment and to establish sustainable development for the construction industry.

When the first European explorers set out across the Atlantic or to the Far East, they did not have the benefit of any synthetic fibres or materials. How did they manage to harness the winds using unwieldy sails? The answer was hemp; hemp was an extremely practical plant having far reaching applications in myriad different industries. Now, on the verge of the second millennium, another plant, bamboo, shows an excellent potential for helping to solve many of the problems associated with the accelerated growth of world population. After almost four decades of research and development into bamboo, there is sufficient scientific information to increase the use of bamboo as a substitute for traditional materials in many applications of the construction industry.

Bamboo grows in abundance in many parts of the world, especially in tropical and subtropical regions. Bamboo forests play an important role in controlling water cycles, reducing erosion and sequestering carbon from the atmosphere. Since the culms of four to five years of age can be effectively used in construction and other engineering products, an increased use of bamboo does not pose a risk for bamboo forests; on the contrary, it will create economic incentives for the farmers to develop bamboo plantations. An increase in the use of bamboo in construction leads to energy savings, conservation of the world's scarce resources and reduction in environmental pollution. Bamboo forests are the most easily available resources for many communities, which can be used to solve one of the most acute forms of human misery – housing problems.

This is also a challenge to the science and skills of engineers accustomed to using well developed technologies. Even though bamboo is a fast-growing, high-yielding and easily renewable natural resource, our ability to use it in durable construction requires more research and development. The structural efficiency of bamboo compared to that of other engineering materials such as steel has been shown, which may be attributed to the high strength of the uniaxial reinforcing fibres and the hollow cylindrical shape of the culm. However, these characteristics along with the geometrical irregularities of the raw material pose challenges to develop efficient and cost-effective structural joints. In addition, the major factors facing the development of durable bamboo constructions are the inherent weaknesses of the material, such as high water absorption and susceptibility to fungal and insect attack. Bamboo contains hemicelluloses, starch, sugar, tannins, certain phenols and lignin, which can be attacked by soluble extractives, preventing it from having a good durability characteristic. Following years of research and development since the 1970s, there is sufficient scientific information to increment the use of bamboo as a substitute for steel in many applications.

This issue presents a varied selection of papers on bamboo, mainly describing applications and tests aimed at improving the mechanical characterisation and standardisation of the material.

Harihar and Verhagen (2017) look into the use of bamboo in a pile wall and drainage system in mangrove rehabilitation projects in India, which proved to be cost-minimising and eco-friendly as the structure integrates with the developing mangrove habitat.

Harries *et al*. (2017) study the effects of geometric and material property variation along the culm length and through the wall thickness on the compressive load capacity of three representative species of bamboo. A realistic and simple estimate of capacity is obtained by considering that the culm have properties calculated at mid-height. The theoretical analyses were validated with experimental data for Moso, Tre Gai and Guadua species. The authors also propose the classification of bamboo as thick- and thin-walled species according to the ratio between diameter and thickness.

Sharma *et al*. (2017) accomplish a multi-laboratory full-scale test programme to investigate mechanical properties of outdoor laminated bamboo using timber test methods. Results show that laminated bamboo has properties comparable to timber and glue-laminated timber, and this forms a foundation for the use of laminated bamboo in design and construction. The study shows that a joined approach to characterisation and standardisation is needed in order for bamboo-laminated products to be accepted in the engineering practice.

The study of Richard *et al*. (2017a) investigates longitudinal shear failure in full culms of *Phyllostachys pubescens* and *Bambusa stenostachya* bamboo through a number of standards and modified test methods in order to show the actual shear-dominated behaviour. Notched specimens were used to better establish relationships between the modes of behaviour.

In the aftermath of an earthquake in the Philippines, Richard *et al*. (2017b) take advantage of the availability, good structural properties and sustainability of bamboo to use it in structural columns and trusses to rebuild two schools. Tests were carried out to determine the strength of bamboo connections for the trusses. The schools were finalised in cooperation with local engineers and craftsmen.

Concluding that current design and construction codes and standards do not contain strength grading procedures beyond cursory visual inspections, Trujillo *et al*. (2017) present a research project seeking to develop a strength grading system for bamboo culms. Tests on *Guadua angustifolia* Kunth were carried out to determine mechanical and physical properties.

Although bamboo has been indicated the most promising building material for decades, technical, normative and cultural challenges have prevented its widespread use in construction. The research of Lorenzo *et al*. (2017) examines the structural use of natural bamboo culms in the modern age and proposes a new design and fabrication framework for high-quality, sustainable and resilient bamboo structures for the 21st century.

Moran *et al*. (2017) have studied the bamboo *G. angustifolia* for its excellent mechanical properties in axial direction. A new protocol has been proposed to determine the circumferential-axial shear and axial Young's modulus by loading slats under torsion and bending. With this protocol, the mechanical properties can be assessed for other bamboo species and wood to be used in engineering.

An experimental investigation by Khatib and Nounu (2017) on the bond between bamboo and concrete using linseed oil was shown to be effective and improved the bond between corrugated splints and concrete. Pull-out tests used to establish the bond between bamboo and concrete. The effectiveness of the application of linseed oil for waterproofing of corrugated and non-corrugated bamboo splints also has been shown to be effective.

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