The 2019 International Bamboo Construction Competition

Kewei Liu, Cristoforo Demartino, Zhi Li, Qinghui Liu, and Yan Xiao

Abstract In 2019, the International Bamboo and Rattan Organisation (INBAR) launched the International Bamboo Construction Competition 2019 (IBCC 2019). IBCC 2019 is an international contest aimed at university students of architecture, civil engineering, landscape, and other construction-related courses. The objective of the competition is to invite students to explore the potential construction applications for both bamboo poles and engineered bamboo products. IBCC 2019 was sponsored by several important companies working in the development of innovative bamboo products for the construction and design industries. The competition was organized on three different stages: pre-selection and qualification; selection of the three projects to be realized; and realization and award of the best project. This chapter opens with a discussion on the nature of the competition and then summarizes the key steps of the IBCC 2019 from the ideation to the award ceremony. The key design goals are widely discussed together with a deep analysis of the potentiality of bamboo for the construction industry.

Keywords IBCC 2019 · Student competition · Bamboo · Temporary structures · Design projects

K. Liu · Q. Liu
International Bamboo and Rattan Organisation, Beijing, China

C. Demartino (✉) · Y. Xiao
Zhejiang University-University of Illinois at Urbana Champaign Institute, Zhejiang University, Hangzhou, Zhejiang, PR China
e-mail: cristoforodemartino@intl.zju.edu.cn

Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA

Z. Li
College of Civil Engineering and Architecture, Zhejiang University, Hangzhou 310058, Zhejiang, PR China

K. Liu
School of Civil Engineering, Tsinghua University, Beijing, China

K. Liu et al. (eds.), *2019 International Bamboo Construction Competition*, Springer Tracts in Civil Engineering, https://doi.org/10.1007/978-3-030-91990-0_1

1 Introduction

Competitions play a role in motivating students to perform and excel and offer a lot more rewards than just the winning prize [1]. Competitions offer a chance for participants to gain substantial experience, showcase skills, analyze and evaluate outcomes and uncover personal aptitude. Competitions also encourage students to adopt innovative techniques and develop their ideas and skills.

Learning by doing refers to a theory of education expounded by American philosopher John Dewey [2]. It's a hands-on approach to learning, meaning students must interact with their environment to adapt and learn. Dewey implemented this idea by setting up the University of Chicago Laboratory School. His views have been important in establishing practices of progressive education. By letting structural engineering and architecture students explore questions using architectural design methods, they creatively and systematically addressed holistic questions while maintaining a technical depth. The approach may serve as a model to increase engineering students' ability to insightfully contribute to solutions for complex societal problems. One way of invigorating engineering and architecture education is to combine engineering with liberal arts, grounding students more firmly in creative and innovative design, social responsibility, and critical thinking. These three outcomes are key to forming our future architects and civil engineers.

The environmental impact of the construction industry contributes to global warming [3]. Construction projects emit large amounts of carbon dioxide and methane. Infrastructure developments cause pollution and produce waste. The construction sector accounts for 36% of worldwide energy demand, and 40% of the global energy and process-related emissions [4]. As the output of the construction industry multiplies, so can its damaging effects. Therefore, a reduction of the environmental impact of the construction industry is necessary. As a matter of fact, sustainability is no more an option but a way of living that we need to rapidly adopt for our survival and sustainability of humanity. In this context, China announced during the 75th session of the UN General Assembly (UNGA 75) will aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060.

The United Nations Sustainable Development Goals (SDGs) adopted by 193 countries at the Paris Accord (COP21) encompass the pressing issues of sustainability, to be addressed holistically on the social, environmental and economical fronts [4]. SDG 11 involves making human settlements sustainable, safe, and resilient. Again, the designers of MEP systems have an important part to play, especially where they can minimize water and energy use. Construction material with better thermal properties can further reduce HVAC plant capacity, with up to 10% reduction achieved due to the use of material with a better heat transfer coefficient. There are numerous ways to decrease the negative environmental impact on your construction project. By utilizing green and reusable technology, keeping project length to a minimum, limiting fuel use, along with other suggestions listed, you are sure to make a difference in the impact on the environment. Thus, it is essential to understand the emission reduction potential of new technological options in the construction industry.

Bamboo is a truly remarkable green building material [5]. Bamboo is a rapidly renewable material that has many applications in construction. Bamboos are a diverse group of evergreen perennial flowering plants in the subfamily *Bambusoideae* of the grass family *Poaceae* [6]. The origin of the word "bamboo" is uncertain, but it probably comes from the Dutch or Portuguese language, which originally borrowed it from Malay or Kannada. Bamboos are of notable economic and cultural significance in South Asia, Southeast Asia, and East Asia, being used for building materials, as a food source, and as a versatile raw product. Bamboo, like wood, is a natural composite material with a high strength-to-weight ratio useful for structures. Bamboo is twice as strong as concrete and slightly stronger than steel. Bamboo has an unparalleled growth rate in the plant world. The world record for the fastest growing plant belongs to certain species of the 45 genera of bamboo, which have been found to grow at up to 91 cm per day [7]. Because the regeneration rate for bamboo forests is much quicker than any other woody plant, it is a far superior sustainable choice. The main drawback in using bamboo is that being a natural material presents large irregularities therefore it is generally difficult to exactly determine its properties (geometrical and mechanical). To overcome this issue, different researchers proposed engineered bamboo products. Engineered bamboo products result from processing the raw bamboo culm into a laminated composite, similar to glue-laminated timber products [8]. These products allow the material to be used in standardized sections and have less inherent variability than the natural material [9].

In 2019, the International Bamboo and Rattan Organisation (INBAR) launched the International Bamboo Construction Competition 2019 (IBCC 2019). IBCC 2019 was launched with the aim to combine all the elements summarized before: competition for students, learning by doing, reduction of the environmental impact of the construction industry, and use of bamboo. This chapter opens with a discussion on the nature of the competition and then summarizes the key steps of the IBCC 2019 from the ideation to the award ceremony.

2 Genesis of the Competition

In 2019, the International Bamboo and Rattan Organisation (INBAR) launched the IBCC 2019. The logo of IBCC 2019 was designed by the students of the organizing committee, see Fig. 1. The logo is inspired by the following elements: international

Fig. 1 Logo of IBCC 2019 (designed by Ke Ma)

by color, bamboo by shape, construction by the view of perspective, competition by the shape of small arrows.

The genesis of this student competition is oriented to the idea that student competitions can inspire architecture, civil engineering, landscape, and other construction-related students to greater achievement. By adding an element of collaboration to the competition (teamwork), the organizers ensured that every student has a chance to participate and achieve the same level of learning as the high-achieving students. The competition aims at improving the idea of environmentally-friendly buildings: structures that are resource-efficient throughout their life-cycle, throughout the processes of design, construction, operation, maintenance, renovation, and eventual demolition. Environmentally-friendly buildings represent a paradigm shift in the field of architecture and a more sustainable way to secure the future of urbanization.

To this aim, the opportunities offered by the use of bamboo (raw or engineered) for construction are explored by IBCC 2019. Bamboo is the fastest-growing and most versatile plant on Earth. For centuries, bamboo has played an indispensable part in the daily life of millions of people in tropical countries. In the last decades, it has gained increasing importance as a substitute for timber. In recent years, the global modern bamboo construction sector has made remarkable achievements: hundreds of large commercial projects are built with bamboo. In November 2018, a quick-assembly bamboo slum housing design won the prestigious "Cities for our Future Challenge" competition, coordinated by the Royal Institute of Chartered Surveyors. However, the capacity building of bamboo construction professionals' lags behind the resources' potential.

IBCC 2019 was established to redress this gap. IBCC 2019 was an international contest aimed at university students. The objective of the competition is to invite students to explore the potential construction applications for both bamboo poles and engineered bamboo products. The general goals of IBCC2019 and expected outcomes are summarized in Fig. 2. IBCC 2019 started with the aim to combine all the elements summarized before: competition for students, learning by doing, reduction of the environmental impact of the construction industry, and use of bamboo.

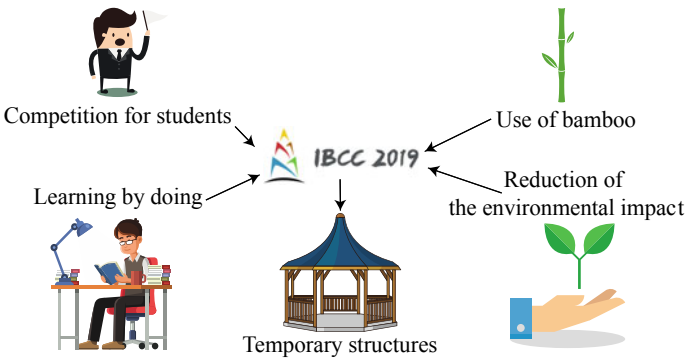

Fig. 2 General goals of the competition and expected outcomes

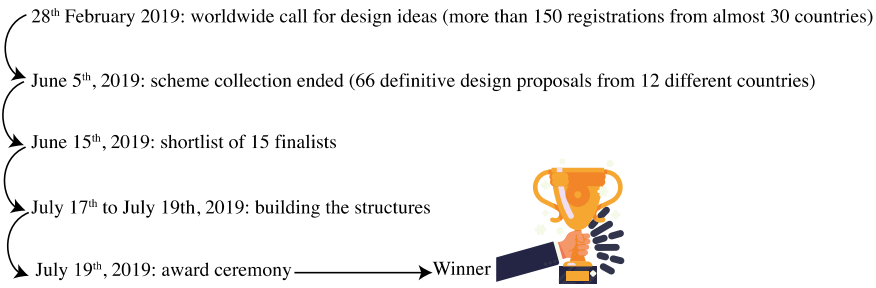

Fig. 3 Timeline of the IBCC2019

The design competition asked to design a temporary structure. These structures are erected to fill a temporary need, lasting for hours, days, weeks, and sometimes months instead of years. A typical temporary structure is designed to provide shelter to people, products, equipment, animals, or anything else which needs to be sheltered from the elements. In particular, IBCC2019 required to design a prototype of a temporary structure for a multi-functional garden building able to operate as a temporary office, warehouse, educational space, or coffee shop with a construction area of 9 m^2. The building is to be made mostly from bamboo poles and/or engineered bamboo products and be characterized by a low environmental impact. Additionally, the building should be easily demountable and transportable, and though it is a temporary structure, detailing known to limit the durability of bamboo should be avoided.

The competition was organized in four stages (see Fig. 3). In the first stage, a worldwide call for design ideas (Sect. 3.1). In the second stage, a jury of 23 members selected a shortlist of 15 finalists (Sect. 3.1). Finally, the top three finalists built the real bamboo house in the INBAR Garden during the 2019 Beijing Horticultural Expo (Sect. 4). At the end of the construction process, an award ceremony was organized at the 2019 Beijing Horticultural Expo (Sect. 5).

3 The Competition: From Registration to the Shortlist

3.1 The Worldwide Call for Design Ideas

The competition was launched on the 28th of February 2019. In the following, the worldwide call for design ideas is reported.

Background Bamboo provides millions of households across the world with employment and building materials. It is often used as a fast-growing alternative to timber or other building materials, and its products can have a low or even negative carbon footprint across their lifecycle. Well-designed bamboo structures are known to withstand earthquakes and tropical storms remarkably well. In recent years, the global modern

bamboo construction sector has made remarkable achievements: hundreds of large commercial projects are built of bamboo. However, the capacity building of bamboo construction professionals' lags behind the resources' potential. IBCC2019 is an international competition aimed at university students of architecture, civil engineering, landscape, and other construction-related courses from across the world. The competition's objective is to invite students to explore the potential construction applications for both bamboo poles and engineered bamboo products.

Context The 2019 Beijing Horticultural Expo is held in Beijing from 29th April to 7th October 2019. At this event, INBAR has a 3000 m^2 Garden, which houses our own 1600 m^2 Pavilion. The pavilion was built from round bamboo poles and engineered bamboo products (Simi et al. A Review on Round Bamboo Structural Applications and Perspectives).

Who Can Participate in the Competition? BCC2019 is open to university students from the departments of architecture, civil engineering, landscape, or other construction-related courses. Full-time on-campus students, includes undergraduate students, master, and Ph.D. candidates, can participate in the competition and should enter as a team. Teams are constituted by one advisor and three students. There should be at least one student from architecture, landscape architecture, or architectural technology, and one student from civil or structural engineering. It is the responsibility of the advisor to demonstrate the structural safety of the design, particularly for any proposal that is to be built in the INBAR Garden of the 2019 Beijing Horticultural Expo.

Topic of the Competition IBCC 2019 is inspired by the 2019 Horticultural Expo and requires entrants to design the prototype for a multi-functional garden building. The design competition asked to design a temporary structure. These structures are erected to fill a temporary need, lasting for hours, days, weeks, and sometimes months instead of years. A typical temporary structure is designed to provide shelter to people, products, equipment, animals, or anything else which needs to be sheltered from the elements. In particular, IBCC required to design a prototype of a temporary structure for a multi-functional garden building able to operate as a temporary office, warehouse, educational space, or coffee shop with a construction area of 9 m^2. The building is to be made mostly from bamboo poles and/or engineered bamboo products and be characterized by a low environmental impact. Additionally, the building should be easily demountable and transportable, and though it is a temporary structure, detailing known to limit the durability of bamboo should be avoided. The following technical characteristics were required:

- A construction area of 9 m^2 (3 m $\times$ 3 m), as well as a projection area no larger than 16 m^2 (4 m $\times$ 4 m), including cantilever structural elements such as canopy. Plat concrete foundation is available for each project.
- The building should be one or two stories. The maximum height of the first floor is 3 m and the total is 5 m. The first floor should be a closed space (also a part is fine) while the second (optional) open. The first floor must have the minimum requirement of one door and one window.

Table 1 Design strength values of engineered bamboo along the bamboo fiber direction in MPa

Bending strength	Compression strength	Tension strength	Shear strength along bamboo strips	Elastic modulus
20	17	8	4	9500

- The indoor temperature should remain pleasant throughout Beijing's summer (around 24–26 °C) without resort to mechanical ventilation or artificial cooling.
- The building should be easily demountable and transportable, and though it is a temporary structure, detailing known to limit the durability of bamboo should be avoided.
- The building is to be made mostly from bamboo poles and/or engineered bamboo products. A limited amount of other non-structural materials may be used, but only with the aim of enabling or enhancing bamboo's potential, or where clearly bamboo is inappropriate. It should be assumed that only Moso bamboo (Phyllostachys edulis) is available for bamboo poles unless otherwise agreed with the organizing committee. Engineered bamboo products available will be announced by the organizing committee. The design strength values of engineered bamboo can be estimated as in Table 1 (if no data from manufacturers is available).
- The total budget for all building materials is USD 10,000, and should not be exceeded. It must be buildable by a team of four people over three days (three 8 h periods).

Requirements of Submission The submission was required to have graphic boards and a descriptive report. In particular, the following specifications were provided to the different teams:

- Graphic boards: 2 graphic boards in vertical on a rigid support, format UNI-EN-ISO A1 containing: plans, profiles, and sections representing the architectural design in scale 1:50; simulations, representations, sketches, profiles, or perspective views (with an appropriate scale) that would be needed to understand the design proposal. Perspective views useful for understanding the project (simulations, photomontage); drawings of constructive details useful for understanding the architectural elements of the used materials and constructive technology, scale 1:10. Processing files must be printed and should not exceed the size of 50 MB for the single file.
- The Descriptive Report: maximum 6 pages plus the cover—A4 format—printed single side on white paper—body character ARIAL 11 pt. Single line—maximum 5000 characters—with pictures or explanatory drawings. The report may contain images and diagrams of the proposal. The report shall illustrate the guiding principles of the choices and description of the design solutions.

On June 5th, 2019, at the end of the worldwide call for design ideas, the IBCC2019 received more than 150 registrations from almost 30 countries. After a preliminary

selection of compliance with the rules of the context, 66 design ideas from 12 countries we accepted to be judged by the jury for to be possibly included in the shortlist of 15 finalists.

3.2 The Shortlist of 15 Finalists

The Jury Committee of IBCC2019 was composed of 23 jurors from the top universities and leading companies in the world in the area of bamboo. The 23 jurors are from different countries so that the equity and transparency of the competition are guaranteed.

Chairman of the Jury Committee is Kai Cui (Fig. 4). Cui Kai is Chief Architect of China Architecture Design and Research Group, Professor of Tianjin University, Practical Professor of Tsinghua University, Professor of University of Chinese Academy of Sciences, and editorial board member of several architectural magazines. He is also the designer of the China Pavilion in the 2019 Beijing Horticultural Expo.

The other 22 jurors of the committee are:

Denamo Addissie, Assistant Professor of Addis Ababa University, Ethiopia.
Yann Olivier Barnet, Director of Institute of Housing, Urban Planning and Construction of the University San Martín, Peru.
Edwin Zea Escamilla, Head of Sustainable Real Estate at the Centre for Corporate Responsibility and Sustainability of the University of Zürich, Switzerland.
Romildo D. Toledo Filho, Professor of Federal University of Rio de Janeiro, Brazil.

Fig. 4 Kai Cui (Chairman of the Jury Committee) during the IBCC2019 award ceremony

Kent Harries, Professor of the University of Pittsburgh, USA.
Sebastian Kaminski, Senior Structural Engineer of Arup, UK.
Sanjeev Kappe, Founder Director of Konkan Bamboo & Cane Development Center, India.
Emmanuel Appiah Kubi, Research Scientist of CSIR-Forestry Research Institute, Ghana.
Gisela Loehlein, Head of Architecture Department Xi'an Jiaotong-Liverpool University, China.
Liu Kewei, Global Bamboo Construction Programme Coordinator of INBAR, China.
Mauricio Cardenas, CEO of Studio Cardenas Conscious, Italy.
Haitao Li, Professor of Nanjing Forestry University, China.
Luis Felipe Lopez, Head of Product Development at Base Bahay Foundation, the Philippines.
Martin Tam, Chair of Federation of Hong Kong Industries Bamboo Industry Committee, China.
David Trujillo, Chair of INBAR Construction Task Force, Assistant Professor of Coventry University, UK.
Yuanfeng Wang, Director of Sustainable Civil Engineering Committee of the Chinese Society for Urban Studies, Professor of Beijing Jiaotong University, China.
Yan Xiao, Professor of Zhejiang University, China.
Qingfeng Xu, Deputy Chief Engineer of Shanghai Research Institute of Building Sciences, China.
Jun Yang, Professor of Tsinghua University, China.
Li Zhang, Chief Editor of World Architecture, Professor of Tsinghua University, China.
Chen Zhao, Professor of Nanjing University, China.
Xi Zheng, Professor of Beijing Forestry University, China.

After several rounds of selection, the jury selected 15 finalists from the total 66 design projects received. The official announcement was given on June 15th, 2019. The 15 finalists are listed in Table 2.

The top three finalist teams in in Table 2 were invited to build the real bamboo house in the INBAR Garden during the 2019 Beijing Horticultural Expo. The description of the projects reported in Table 2 is provided in this book in the next chapters.

4 The Top Three Finalists: Building the Structures

The top three finalist teams were invited to the 2019 Beijing Horticultural Expo to build the proposed design project from July 17th to July 19th, 2019. The three teams were from Europe, Africa, and China. The three finalists proposed quite different

Table 2 Fifteen finalists selected from the jury

Name	University	Advisor	Team 1	Team 2	Team 3
House Loti	Université de Liège ULiege	Vincent Denoël	Audrey Mertens	Fantine Fontaine	Chen Qi
In-Box House	Addis Ababa University	Boja Muluneh	Lelissa Erkissa	Mikyas Tekle	Simon Mucheye
Machine of bamboo	Nanjing University	Xiao Fu	Huimin Wu	Xiaonan Li	Sicheng Zhou
Crouching · hidden	Beijing Jiaotong University	Zeng Zhongzhong	Cai Yueqian	Qian Xiaowen	Liu Dingyi
Nomad	University of Chinese Academy of Sciences	Ren Congcong	Yang Jindi	Jin Liu	Yan Xin
Bloom	Zhejiang university	Zhuo Xin	Yang Chenchen	Rui Guanbao	Wang Chidi
Confronting the performance of bamboo in architecture	Ethiopian Institute of Architecture, Building Construction and City Development	Alemayehu Sargo Dalibiso	Ermias Fentaw Marye	Beka Debela Chali	Yeneneh Tefera Negash
A Flower A World	North China University of Technology	Zhao Xiangdong	Zhao Sijia	Zhang Hongmei	Zhang Ziwei
Bamboo field	Xiamen University	Lin Yuxin	Zhang Yin	Qin Ruonan	Gong Qing
Push and pull varying tranquility bamboo tectonic	Xiamen University	Yuxin Lin	Sihan Wang	Yu Wang	Hao Qiu
Bending Blossom	Xi'an Jiaotong Liverpool University	Thomas Alois Wortmann	Zhao Zhang	Henry Pantin	Caipeng Yan
Ternary shed	The University of Queensland	Kimberly Baber	Mateo Gutierrez Gonzalez	Harry Frazer Mills	Hamish Buchhorn
The bud pavilion	Xiamen University	Lin Yuxin	Urali Halimati	Guo Yanfang	Hong Yangyi
Bamboo's verve	Chongqing Jiaotong University	Biao Huang	Xinrui Wei	Jiping Ma	Junfeng Xiong
Name	Xi'an Jiaotong-Liverpool University	David Vardy	Shi Luhang	Gao Xinxin	Xie Haitian

design ideas. The first two projects were based on raw bamboo (House Loti and In-Box House, see Table 2) while the last one was on engineered bamboo (Machine of Bamboo, see Table 2). Moreover, the project Bloom (see Table 2) realized the structure although not selected in the top three finalist teams.

A collection of photos of the three days of construction at the 2019 Beijing Horticultural Expo to build the proposed design project from July 17th to July 19th, 2019, is reported in Fig. 5. The students helped by some local workers worked for three full days to build the structures. At their arrival, they found only ready the foundations of the structures made of reinforced concrete. The final structures realized are shown in Fig. 6. These structures are described in Mertens et al. House Loti; Erkissa et al. In-Box House; Wu et al. Machine of Bamboo.

House Loti combines Western and Eastern construction, the traditional and the modern, to create a pavilion building that is adaptive, sustainable, and pleasant. The word "blossom" inspired a dynamic design, being able to actually bloom: petals composing the walls of the closed flower can blossom into sunshade panels and seats.

Fig. 5 Some photos of the three days of construction at the 2019 Beijing Horticultural Expo to build the proposed design project from July 17th to July 19th, 2019

Fig. 6 Top three realized finalist projects. (Left: House Loti from the Université de Liège; center: In-Box House from Addis Ababa University; right: Machine of Bamboo from Nanjing University)

In-Box House is a multifunctional bamboo garden house designed to be constructed in a combination of bamboo poles with prefabricated bamboo lumber. The prefabricated modular bamboo lumbers with simple connection details make it easy to be constructed on-site. The prefab modular boxes are inserted in the bamboo structural frames in many functional layouts according to the functional purposes.

Machine of Bamboo originates from the desire of relaxing in nature. This building has two stories. The construction is covered by a type of semi-transparent material, sunshine board, which is not only easy to install but also keeps privacy and creates good daylighting. Engineered bamboo is used as the main structural material. The building is easily demountable, transportable, and reusable. Even though it is a temporary structure, the long-term durability of structural members has been guaranteed.

5 The Award Ceremony

On July 19th, 2019, the award ceremony hold place at the INBAR Garden Pavilion—Bamboo Eye (see Fig. 7). During the event, three finalist projects presented the structures to the jurors. Moreover, the remaining selected 15 finalists presented their design ideas.

The jurors selected the best projects in the following order:

1. House Loti, designed by a team from Université de Liège. (Team: Audrey Mertens, Fantine Fontaine, Chen Qi; Advisor: Vincent Denoël)
2. Machine of Bamboo, designed by a team from Nanjing University. (Team: Huimin Wu, Xiaonan Li, Sicheng Zhou; Advisor: Xiao Fu)

Fig. 7 Group photo during the award ceremony on July 19th, 2019 in front of the Inbar Garden Pavilion—Bamboo Eye

3. In-Box House, designed by a team from Addis Ababa University. (Team: Lelissa Erkissa, Mikyas Tekle, Simon Mucheye; Advisor: Boja Muluneh)

6 Conclusions and Future Developments

IBCC 2019 demonstrated the potentiality of the use of bamboo in constructions. IBCC 2019 received more than 150 registrations from almost 30 countries, and 66 final design ideas from 12 countries. A jury with jurors from top universities and leading companies around the world selected a shortlist of fifteen finalists and three projects to be realized. The three projects were successfully designed and showed high quality; the next chapters will describe them in a detailed way.

As a suistanable and fast-grown resource, with superior physical and mechanical properties, bamboo offers great potential as an alternative to wood. The bamboo-based industry has vast potential for generating income and employment, especially in rural areas. Therefore, future editions of this context should deeply explore the potentiality of bamboo in constructions.

Acknowledgements IBCC 2019 was sponsored by Ganzhou Sentai Bamboo Wood Company of China, Hongyazhuyuan Science and Technology Company of China, Zhujing Bamboo Company of China and Beijing Sino-bamboo Culture and Technology Limited Company.

References

1. Verhoeff, T. 1997. The role of competitions in education. *Future world: Educating for the 21st Century*, 1–10.
2. Thompson, P. 2010. Learning by doing. *Handbook of the Economics of Innovation* 1: 429–476.
3. Lin, B., and H. Liu. 2015. CO_2 mitigation potential in China's building construction industry: A comparison of energy performance. *Building and Environment* 94: 239–251.
4. Bebbington, J., and J. Unerman. 2018. Achieving the United Nations sustainable development goals. Accounting, Auditing & Accountability Journal.
5. Wang, J.S., C. Demartino, Y. Xiao, and Y.Y. Li. 2018. Thermal insulation performance of bamboo-and wood-based shear walls in light-frame buildings. *Energy and Buildings* 168: 167–179.
6. Liese, W., and M. Köhl. 2015. *Bamboo-the plant and its uses*. Tropical Forestry: University of Hamburg.
7. Guinness World Records webpage. https://www.guinnessworldrecords.com/world-records/fastest-growing-plant/. Last accessed 26 Apr 2021.
8. Sharma, B., A. Gatóo, M. Bock, and M. Ramage. 2015. Engineered bamboo for structural applications. *Construction and Building Materials* 81: 66–73.
9. Xiao, Y., Q. Zhou, and B. Shan. 2010. Design and construction of modern bamboo bridges. *Journal of Bridge Engineering* 15 (5): 533–541.