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Examining the transformative potential of bamboo construction

Developing bamboo in the Haitian built environment

John Naylor and Jane Wynne

Haiti suffers from chronic deforestation that amplifies flooding and landslides caused by hurricanes and storms.[1] More than 60% of Haiti has a slope greater than 20%, and almost 30% of land has slopes less than 10%.[2] The loss of forest cover results in the loss of the topsoil through erosion and increases the probability of flooding,[3] a process that began with the French colonial plantation system.[4] A great number of Haiti's watersheds are entirely deforested and subsequently urbanised, and much of the soil is highly degraded *[1]*.[5] This topsoil from the hillsides around Port-au-Prince has poured down the slopes and added more area to the city due to soil deposits. Such poorly compacted land – the locations presented in the soil classification map in CNBH 2012[6] (the Haitian Building code) – can amplify ground motion and the risk to buildings in earthquakes.[7]

On 12 January 2010, an earthquake hit Port-au-Prince, Haiti's capital, causing a catastrophic death toll.[8] A lack of lightweight building materials, and lack of enforcement of building standards and codes played a significant role in this disproportionately high number.[9] Over half of the contemporary built stock, constructed predominantly of poorly reinforced or unreinforced

1 Steep, deforested hillsides to the south east of Kenscoff, Haiti, south of Port-au-Prince.

masonry, collapsed in the epicentral area, or was damaged enough to require repairs.[10] The need for safe and lightweight buildings in Haiti is critical. Poor quality construction, due to expensive building materials, only exacerbates this problem. Most of these materials need to be imported, and the expensive cost of mineral rich *sab rivyè* leads to the widespread use of calcite sand, which is unsuitable for concrete. Due to a lack of resources, most housing in urban areas in Haiti uses a combination of reinforced concrete columns and unreinforced masonry walls made of concrete masonry units (CMUs) *[2]*.[11] The enforcement of building codes, such as Haiti's national building code, CNBH, are difficult when most low-income homes are built informally and are unlikely to seek building permission.[12]

Haiti grows species of bamboo such as *Guadua angustifolia*, which is codified for structural use in Colombia *[3]*.[13] This species has also been used to construct in Croix-des-Bouquets and Cabaret, in Haiti. The availability of such species makes Haiti an opportune location to apply this lightweight material for construction, to restore ecologies, and support economic development. The name Haiti (or Ayiti) comes from the indigenous pre-Columbus inhabitants, the Taino, and means 'Land of High Mountains'.[14] Even this name highlights the opportunity for bamboo construction, since bamboo grown on slopes can have higher fibre density and increased strength properties.[15] Beyond this, bamboo forests play an important ecological function, enabling soil and water conservation.[16] Bamboo plantations can exacerbate landslides by creating a *weak slip plane* just below the soil surface.[17] But with careful consideration of site, species, and other adjacent plants, such as deep rooted vetiver grass, some bamboo species can help decrease surface soil erosion and can stabilise river banks. The leafy mulch that is common around bamboo clumps protects the topsoil from erosion by the direct impact of rain.[18]

2 Chalky limestone aggregates used in construction in Port-au-Prince, Haiti, in 2012 seen two years after the devastating earthquake of 2010.

3 The bamboo species of Guadua angustifolia is well documented in the Colombia building code. Bamboo is the primary structural material in some campus buildings at the Universidad Tecnológica de Pereira, in Pereira, Colombia.

Prototyping bamboo construction in Haiti

Haiti needs safe buildings. However, for lasting change, these should be designed in Haiti by local design and construction professionals, and should not be so-called 'air drop solutions'.[19] As Merkel and Whitaker put it, to move away from concrete towards sustainable, lightweight materials, 'Haiti would need a new generation of builders adept at pounding nails rather than mixing cement'.[20] Local designers have an important role in creating visions for clients to invest in bamboo buildings, but also in designing practical and durable structures. Bamboo structures need to be desirable, culturally relevant, functional, and strong.

In this vein, between 2014–17, the authors organised five architectural design and build workshops across Haiti focusing on building capacity for design awareness in bamboo. John Naylor from the Architectural Association School of Architecture, London, planned the academic programme. This was based on a theoretical rationale defined by Jane Wynne, from the Wynne Farm Ecological Reserve in Haiti, with a multitude of further individual and institutional support. The AA Haiti Visiting School as it became known (or AAVS Haiti) aimed to foster skills and champion bamboo as a sustainable construction material. Working with Haitian and overseas participants, the curriculum blended computational design and hands-on bamboo construction. Small groups developed concept designs, which displayed the opportunity for bamboo *[4]*.

Awareness of local challenges, practices, and architects' roles is essential when introducing a new

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4 Student work produced during the AAVS Haiti 2016 summer workshop. Participants designed core housing to be constructed using a full-culm bamboo primary structure.

material, especially one which might have negative societal attitudes attached to it, particularly so in this instance where building infrastructure is heavily reliant on concrete. Throughout the AAVS Haiti programme, this consistently posed a challenge. A deep understanding of the cultural and social context is pivotal for long-term material cultural change in construction. Attitudes to bamboo construction in Haiti are not dissimilar to those in other bamboo growing regions, which parallel the challenges faced by timber construction in Europe and the US. The way to address this requires localised responses.

On 27 May 2022, a symposium was held as a joint event between the Wynne Farm Ecological Reserve in Haiti, Newcastle University from the UK, and the University of Pittsburgh in the US. This symposium aimed to bring those with knowledge and interest in bamboo together to provide a platform for voices from the Haitian built environment to explore real-world challenges and identify the opportunities for alternative materials to concrete and steel.

Among the participants in the symposium was Jupille Facile, a former alumnus of AAVS Haiti and founder of *Bambou Facile*, a bamboo contractor and advocacy organisation. Isabelle Jolicoeur, a local architect, educator, and founder of *Aetypik*, a media platform that worked closely with the AAVS Haiti throughout the workshops. Nancy Leconte, a course tutor on three workshops in 2016 and 2017, and Rose Di Sarno, a Los Angeles-based architect and course tutor on three workshops from 2014 to 2016. The session was moderated by John Naylor, who asked pre-determined questions, and Elrica Metayer, an architect and educator in Haiti, who moderated the audience questions and contributed to the discussion. Questions were written prior to the event and shared with the participants one week prior to the session. What follows presents a summary of the discussions of the symposium.

Haitian construction and design professionals

It is hard to put an exact percentage on the number of buildings in Haiti that involve an architect or pursue regulatory approval. It is common knowledge, however, that the vast majority of construction in Haiti does not seek approval from a regulatory body. A significant proportion of buildings in Haiti are self-built. An indication of this is the ratio of architects per capita, estimated at one per 40,000. The actual approvals process in Haiti was noted to be geared towards establishing taxable assets, without adequate capacity to enforce code compliance or structural verification.

The public discourse on architecture and design can impact the informal construction sector in Haiti. For example, the architect is often referred to as an engineer: in many cases the word architect does not appear in conversation. When such situations occur, it is an opportunity to educate people and to draw attention to the role of an architect to foster conversation. An example of this is Aetypik, an online platform created in 2015 to showcase Haitian creativity and a virtual library of projects to make the architecture and urban design scene more accessible in Haiti. The Haitian licencing body for architects and engineers, the *Collège National des Ingénieurs et Architectes Haïtiens* (CNIAH), is making efforts to be more present in the public realm and to share training for professionals. The Internet has been an important tool for this, with an online register for architects and engineers. There is also *Kout Kreyon*: an initiative to connect and network young architecture, engineering, and construction professionals in Haiti.

In Haiti, it can be an effort to accompany a client throughout all the steps of design and construction, and to reinforce principles and maintain the needs of the end user, particularly where they are not the same person or organisation. The role of the architect in Haiti is dependent on good communication and interpersonal skills. Software can facilitate this, conveying design intent and reassure the client of progress. The design process followed by practicing architects in Haiti varies. However, there is significant use of Autodesk AutoCAD,[21] and Building Information Modelling (BIM) platforms such as Autodesk Revit. This allows offices to be more efficient and more productive, aiding the management of multiple projects at once. Not every practice in Haiti employs these tools but they are more mainstream than previously. Nevertheless, Haiti does not appear on the list of countries that receive software support, and even credit cards from Haiti are often not accepted. So there are obstacles in mainstreaming software in architecture, engineering, and construction professions in Haiti. The cost of licences is a big issue for the future capacity of designers. This is compounded by basic infrastructural challenges that confront software use such as inconsistent electricity provision or Internet access.

Materials, culture, and cost

Project clients seldom consider sustainability. Life in Haiti is sometimes described as 'urgency living', whereby immediate problems make it difficult to think years into the future. In Haitian building construction, clients typically ask for 'fast' and 'cheap', and rarely make environmental requests. Cost cutting typically

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impacts quality. A common occurrence, if not checked by professionals onsite, is steel rebar quality, which can, for example, reduce the performance of reinforced concrete columns. Material quality is also impacted by the need to import, which is significantly affected by inflation and currency fluctuations. Additionally, consumer protection is almost non-existent given the distance between producer and user involving imported materials. An example of this is in the imported steel, in which the dimensions of steel rebar are either wrongly advertised, or there is a lack of education in required specifications for use, resulting in the cheapest being ordered. Even those who do have the means to order to a suitable specification will sometimes find the wrong steel is delivered, it is of inadequate quality, or it is non-crenelated.

In Haiti, material purchasing roles are described as 'blurred' and 'informal'. In many cases, whoever the builder is – or, in the case of self-build projects, the end user – may be purchasing materials without any construction or material knowledge. In some cases, the client may have already purchased materials at the outset of the project. There is a suspicion of the contractor or architect purchasing materials, with concerns that contractors inflate prices to take a cut. When clients buy their own construction materials, they do not know the necessary specification or quality. In the case of concrete blocks, these sometimes can just deteriorate in your hand at the point of sale. This highlights the limited role of the architect or engineer to ensure material quality since ultimately the purchasing is going to be done by someone else. Good design, translating to a good quality building, requires a good quality of material. The builder – or *'boss'* – may be onsite all day, but in certain cases the architect or engineer will just come by once or twice a week. Physical absence of the architect or engineer creates a 'mistrust of professionals' that architects have to deal with. Therefore, before the project even kicks off, the architect has to justify and communicate their role.

There is potential for locally sourced materials to alleviate such problems. Locally sourced bamboo becomes an opportunity to decouple material costs from currency fluctuations and import problems. And it permits a proper bamboo preservation treatment and the inspection of material before purchase and delivery to site. The main challenge to bamboo or timber as an alternative to steel and concrete materials is a security concern, because insurance companies will not insure. A prevalent issue is that Haiti (more precisely Port-au-Prince) is experiencing extensive social and economic instability. So, a client may say 'OK, this is nice you've offered something different [bamboo], but, all in all, if someone fires bullet at my house, am I going to die?'.

Lightweight bio-based materials thus remain absent from the material palette of architects and engineers in favour of concrete masonry. A local lack of timber and timber construction expertise has made it more expensive to build with timber and social perceptions changed after major fires throughout Port-au-Prince and Jacmel, which pushed the cities to forbid use of wood in construction.

As seen with the renowned Gingerbread architecture of the nineteenth century,[21] Haiti was once a regional pioneer of timber frame construction *[5]*. Indeed, traditional timber construction has proved seismically resistant and many such structures survived the devastating 2010 Port-au-Prince earthquake. Gingerbread houses were built by skilled Haitian carpenters with an impeccable technique. Though originally an architecture for the elite, the style was influential, was copied and can promote the use of timber.

Haiti needs to diversify the construction material palette and provide inexpensive, locally sourced, quality materials. Lasting change to Haiti's construction sector change needs to be driven by local architects. Gingerbread architecture, indeed, provides a helpful precedent, thinking of Haitian architects who travelled to France in 1895 and returned to adapt the local resort style in response to local climate and culture. Innovation towards a new way of building has thus occurred before.

Bamboo in public and private building

Concrete has become prevalent in the consciousness of Haitian society as a modern, highly efficient, and fast material to build with. There is also the legacy of a 1925 ban on timber construction, which followed a fire in Port-au-Prince.[22] People *like* concrete, and it is perceived as easy to work with. The abundance of professionals who know how to work with concrete, mixed with a lack of alternatives, makes masonry construction a relatively low-cost 'go-to' means of construction. Further, there is a perceived link between natural materials and poverty, and therefore a perceived relationship with social status. This could, perhaps, be changed if bamboo was to be used in major buildings where the bamboo could demonstrate both structural adequacy and aesthetics.

Maintenance and additional costs would be a consideration with

5 A visit to the Gingerbread House, Maison Dufort, in the neighbourhood of Bois Verna, Port-au-Prince, as part of the AAVS Haiti 2016 course. Restoration by Fondasyon Konesans Ak Libète (Foundation for Knowledge and Liberty).

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timber and bamboo. As would be material availability, which could delay projects and a project programme already vulnerable to security issues. Another challenge is a current lack of knowledge in the construction sector.

When aware of the seismic risk, roughly 80% of thirty families that a symposium participant worked with responded that they preferred bamboo as a material, but they did not have the necessary skills and could not conceive a bamboo design that they would want to live in. Therefore, they chose concrete.

There is thus a combination of a lack of expertise, trust in new or unfamiliar construction materials, and psychological challenges in envisaging a liveable bamboo space; a series of factors that in combination present significant problems. Establishing design and construction capacity for bamboo, and presenting designs to the public, is critical for bamboo to be accepted by clients and end users alike. There would likely be no push back from clients if bamboo were to be suggested for elements like doors and windows, or shades. But clients are afraid to use it for more structural elements.

A market for bamboo could incentivise those with rural land to make money from planting bamboo. Since many of those who have migrated to the city from rural areas still own land in rural areas, this is an opportunity potentially available to even some of the poorest citizens in urban Haiti. As bamboo is introduced slowly into the public eye through projects, people will be interested in the economic opportunity that it creates. Cost remains a major consideration, but it is important to think too in terms of *value*. Clients in Haiti would invest in what is right, but if a client does not understand bamboo construction, or does not believe in it, a lower cost would not matter. Indeed, a potential first disaster with a bamboo structure risks crushing the whole endeavour instantly. Those who design and build with bamboo need to ensure their buildings are durable and well-constructed. The moment people see bamboo is a material that is accepted, it is easier for it to be trusted and copied.

A key challenge is that architecture in Haiti is not experienced equally

Big houses are hidden behind walls, and even places that are meant to be public are frequently concealed. Many are typically unaware that certain buildings are public. Possibilities have been considered for a bamboo-built culture centre and a current project on the island of La Gonave to the west of the Bay of Port-au-Prince. This project is a small market, and can become a space where visitors could engage with the bamboo itself.

Moving from larger public buildings to an element smaller than building scale, there is also an opportunity to replace basic '2x2' timbers with bamboo in the framing of roofing. This would need to be correctly articulated. Bolts or screws are required, not nails since ISO 22156 makes clear that driven nails or staples shall not be used to connect structural bamboo members unless as part of the construction of bamboo shear walls.[23] This application for bamboo could be significant for the large proportion of Haitians who live in so-called '*tol*', or metal sheet roofing houses. Many in the population are now converting to concrete roofing, particularly in areas with recent memories of hurricane damage to timber roofing, but a well-constructed bamboo roofing frame with metal sheet roofing could be a viable alternative system.

A roadmap for bamboo construction

People who grew up in Cap Haitian, the country's second city, were surrounded by people using bamboo for baskets. Education is the catalyst to convert attitudes from seeing it as a craft material to a building material. As discussed here, a material associated with crafts does not immediately exude construction material strength. Education in, and visibility of, bamboo construction is a potential catalyst to raise awareness, although fears of security remain a barrier.

Bamboo buildings should be seen widely. They could be demonstrated at a public event or fair, although the structures would need to be permanent. If seen only as a one-off novelty, it is difficult to demonstrate how the material reacts to everyday use and how it can be inhabited. The most meaningful application of bamboo in the longer term would be to introduce bamboo into housing, although this should perhaps not be in the poorest neighbourhoods, because of wider societal perceptions. This remains important. Conversely, if someone wealthy or famous were to use bamboo, or an institution or indeed a restaurant, then the wider effects could be positive. A hospital typology could also be a possibility, since society associates hospitals with safety, protection, and care.

In the light of climate change, Haiti has the potential to serve as an exemplar for a wider global shift away from manufactured building materials such as concrete and steel. In Haiti, unique vulnerabilities exacerbate global trends into acute local catastrophes. It may be a distinctively challenging context to introduce bamboo as a construction material, but it could be one of the most impactful and economical. As discussed here, with enough local demand for lightweight natural renewable materials from clients, those with barren unproductive land in Haiti could see an economic benefit from planting trees and bamboos. Design professionals and engineers have capacity to promote non-standard bio-based materials, and demonstrate that these materials are affordable, durable, and provide functional space. Over time, a growing body of built projects can also influence the informal sector. There is huge potential.

The 'Bamboo in Haitian Construction' symposium took place in a hybrid format at the Swanson School of Engineering, Benedum Hall, University of Pittsburgh, Pittsburgh, United States, 27 May 2022, in partnership with Newcastle University, UK and the Wynne Farm Ecological Reserve, Haiti.

Notes

1. Laurent Dubois, 'Who Will Speak for Haiti's Trees?', *New York Times*, 17 October 2016.
2. UNCCD, 'Third National Report of the Republic of Haiti - Executive Summary' (2006).
3. Ose Pauleus and T. Mitchell Aide, 'Haiti Has More Forest Than Previously Reported: Land Change 2000–2015', *PeerJ*, 8 (2020), e9919.4
4 Alex Bellande, 'Haïti Dans Le Marché Mondial Du Bois Aux 19ème Et 20ème Siècles: Commerce Et Environnement', *Journal of Haitian Studies*, 22 (2016), 130–46.
5. Marc J. Cohen, 'Diri Nasyonal Ou Diri Miami? Food, Agriculture and Us-Haiti Relations', *Food Security*, 5 (2013), 597–606.
6. CNBH, 'Code National Du Bâtiment D'haïti', ed. by Ministère

https://doi.org/10.1017/S1359135523000313 Published online by Cambridge University Press

des Travaux Publics Transports et Communications (Ministère des Travaux Publics Transports et Communications, 2012), p. 200.
7. William B. Joyner, Richard E. Warrick, Thomas E. Fumal, 'The Effect of Quaternary Alluvium on Strong Ground Motion in the Coyote Lake, California, Earthquake of 1979', *Bulletin of the Seismological Society of America*, 71 (1981), 1333–49.
8. Athena R. Kolbe, Royce A. Hutson, Harry Shannon, Eileen Trzcinski, Bart Miles, Naomi Levitz, Marie Puccio, Leah James, Jean Roger Noel, Robert Muggah, 'Mortality, Crime and Access to Basic Needs before and after the Haiti Earthquake: A Random Survey of Port-Au-Prince Households', *Medicine, Conflict and Survival*, 26 (2010), 281–97.
9. Peter Haas, 'When Bad Engineering Makes a Natural Disaster Even Worse', TED (2010) <https://www.ted.com/talks/peter_haas_when_bad_engineering_makes_a_natural_disaster_even_worse> [accessed 13 July 2020].
10. Reginald Desroches, Mary Comerio, Marc Eberhard, Walter Mooney, Glenn Rix, 'Overview of the 2010 Haiti Earthquake', *Earthquake Spectra*, 27 (2011), S1–S21.
11. Tracy Kijewski-Correa, Alexandros A. Taflanidis, Dustin Mix, Ryan Kavanagh, 'Empowerment Model for Sustainable Residential Reconstruction in Léogâne, Haiti, after the January 2010 Earthquake', *Leadership & Management in Engineering*, 12 (2012), 271–87.
12. Duong Huynh, Janaki Kibe, Josie McVitty, Delphine Sangodeyi, Surili Sheth, Paul-Emile Simon, David Smith, 'Housing Delivery and Housing Finance in Haiti: Operationalizing the National Housing Policy' (Oxfam America, 2013).
13. NSR-10, 'Nsr-10: Título G – Estructuras De Madera Y Estructuras De Guadua', ed. by Ministerio de Ambiente Vivienda y Desarrollo Territorial (Ministerio de Ambiente Vivienda y Desarrollo Territorial, 2010).
14. Laurent Dubois, *Haiti: The Aftershocks of History* (New York, NY: Henry Holt and Co., 2012).
15. Walter Liese, and Thi Kim Hong Tang, 'Properties of the Bamboo Culm', in *Bamboo: The Plant and Its Uses*, ed. by Walter Liese and Michael Köhl (Springer, Cham, 2015), pp. 227–56.
16. Ratan Lal Banik, 'Bamboo Silviculture', in *Bamboo: The Plant and Its Uses*, ed. by Liese and Köhl, pp. 113–74.
17. Hui Yang, Zhengyi Cao, Xueliang Jiang, Yixian Wang, 'Experimental Study on the Deformation and Mechanical Properties of Bamboo Forest Slopes', *Applied Sciences*, 13 (2022).
18. Ben-Zhi Zhou, Mao-Yi Fu, Jin-Zhong Xie, Xiao-Sheng Yang, Zheng-Cai Li, 'Ecological Functions of Bamboo Forest: Research and Application', *Journal of Forestry Research*, 16 (2005), 143–7.
19. Cameron Sinclair, 'The Role of the Architect in Rebuilding Haiti: To Compete or to Construct?', *Huff Post* (2010) <https://www.huffpost.com/entry/the-role-of-the-architect_b_453905> [accessed 16 July 2020].
20. Jayne Merkel and Craig Whitaker, 'Rebuilding from Below the Bottom: Haiti', *Architectural Design*, 80 (2010), 128–34.
21. Gingerbread timber-framed architecture was designed with raised foundations, shaded and well-ventilated spaces, which align with the modern durability guidelines of ISO 21887:2007 for timber and ISO 22156:2021 for bamboo. Regrettably, in many contemporary timber and bamboo structures seen worldwide today, these techniques are often overlooked. See: Columbia University GSAPP, 'The Gingerbread Houses of Port-Au-Prince, Haiti' (New York, NY: Columbia University, 2016), p. 82.
22. Randolph Langenbach, Stephen Kelley, Patrick Sparks, Kevin Rowell, Martin Hammer, Olsen Jean Julien, 'Preserving Haiti's Gingerbread Houses: 2010 Earthquake Mission Report', ed. by Erica Avrami (World Monuments Fund, 2010).
23. ISO 22156, 'Bamboo Structures – Bamboo Culms – Structural Design (Iso Standard No. 22156:2021)' (ISO/TC 165 Timber structures, 2021).

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Competing interests
The authors declare none.

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Jane Wynne was born in Carrefour and is a steward of the Wynne Farm Ecological Reserve in Kenscoff, Haiti. The farm prioritises soil conservation, employing terracing and environmentally friendly cultivation techniques. Building on the farm's foundational practices, Jane addresses Haiti's deforestation and advocates for sustainable agricultural approaches. She studied at Union School in Haiti and 'Anna Maria College, Paxton, Massachusetts, United States, earning a degree in Sociology. She has collaborated with several organisations including the Federation of Friends of Nature, GAFE, Her Many Voices, Earth Givers, and the Smallholder Farmers Alliance.

John Naylor is a UK-based architect and educator at the AA Visiting School. He gained his diploma at the Architectural Association in 2013, winning the Foster's Prize for Sustainable Infrastructure. He has worked at MAD, Beijing and Grimshaw Architects, London. In 2014 he set up the AA's bamboo Visiting School programme in Haiti, which continues as the AA-ITB BambooLab global programme. He is currently studying for a PhD at Newcastle University examining capacity-building design awareness for bamboo, incorporating digital tools, with a continued focus on Haiti.

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