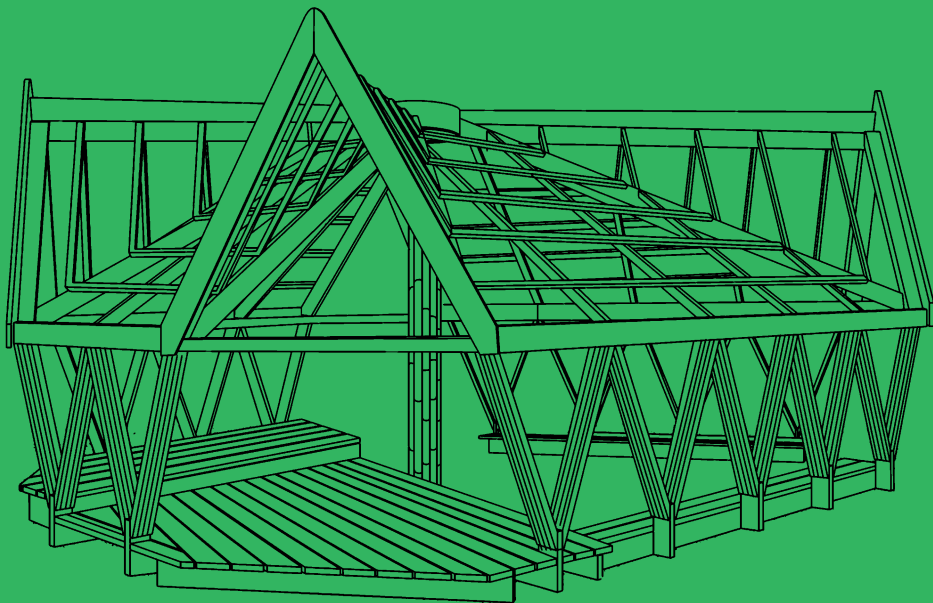


Green Belt Movement

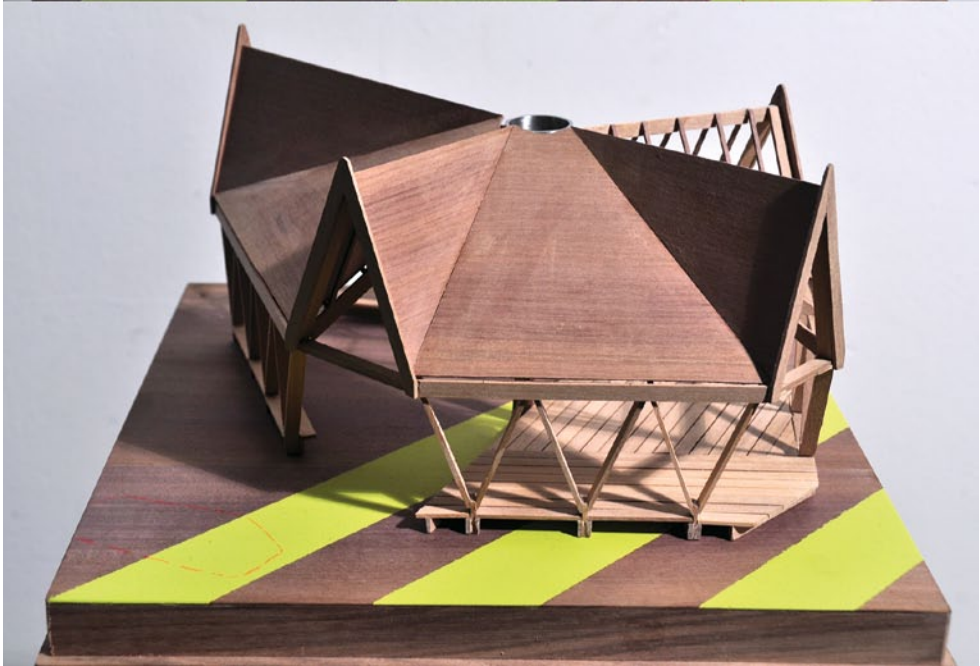
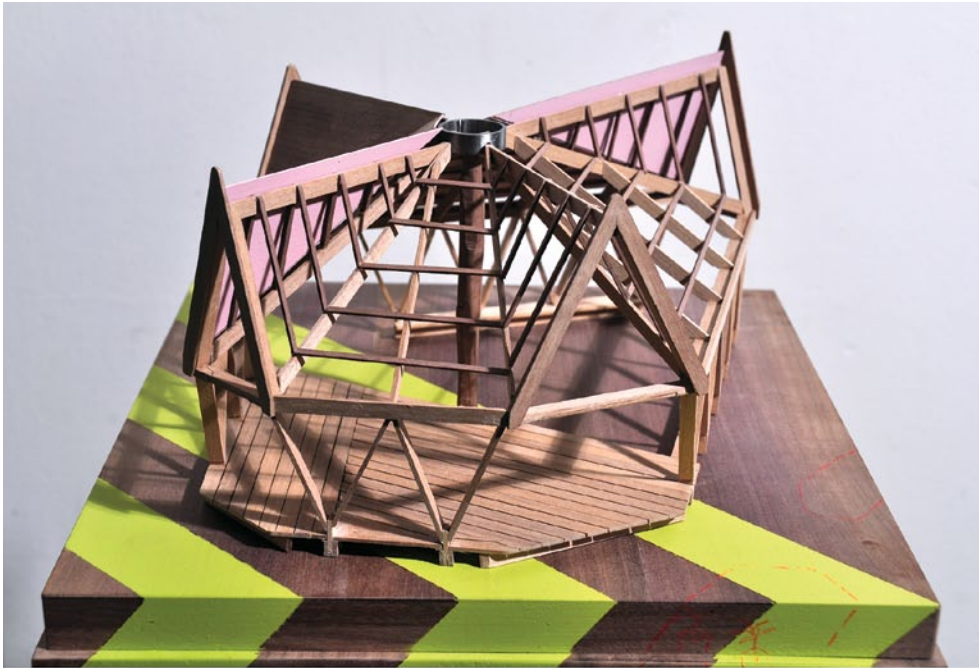
Teaching and Learning Pavilion



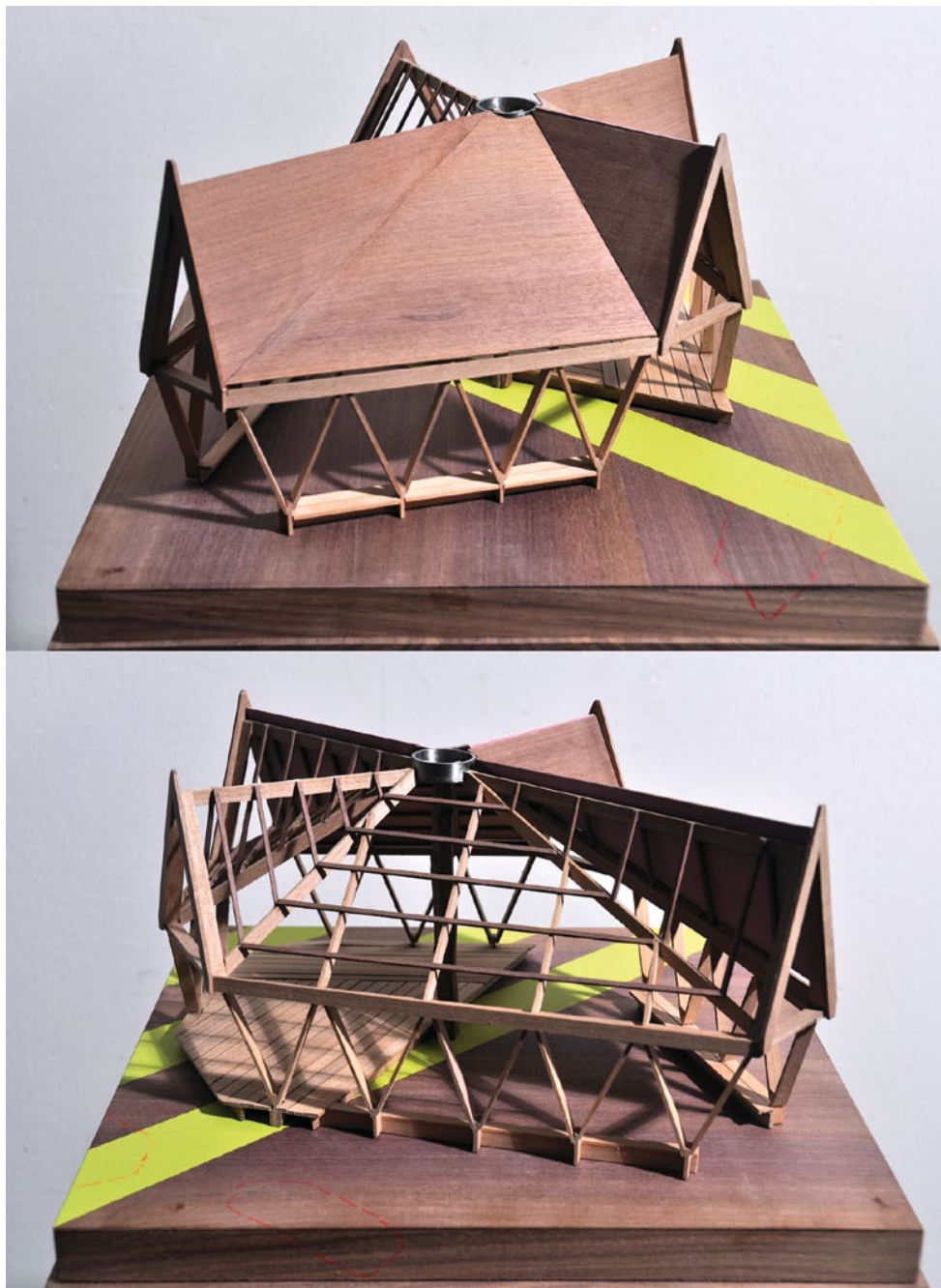
by Patrick Weber

Project Details

Designer:	Patrick Weber
Title:	Green Belt Movement Teaching and Learning Pavilion
Output type:	Design
Function:	Demountable shelter for meeting, teaching and learning
Location:	Kilimani Lane, Nairobi, Kenya
Client:	Green Belt Movement non-governmental organisation
Construction budget:	\$25,000 approx. cost per pavilion
Area:	94m ²
Project collaborators:	John McAslan + Partners, London (project initiators); Planning Systems Services Ltd, Nairobi (local project architects and quantity surveyors); Palm Centre, Kew Gardens, London (bamboo supply)



1a



1b

1
Final model of
the GBM pavilion
showing the
different elevations

Statement about the Research Content and Process

Description

This project looks at strategic design principles for the making of temporary shelters in developing countries. It is a response to a call to design a teaching and learning pavilion for the Green Belt Movement, a non-governmental organisation (NGO) based in Nairobi that fights deforestation. The brief was to research and design a 'learning and meeting space' for their headquarters. Despite the specificity of the brief, the research focused on the broader issues and problems of designing a project with limited funding, materials and skill base in Kenya. The aim was to devise an economic, sustainable and simple structural method that could be adapted elsewhere according to need.

Questions

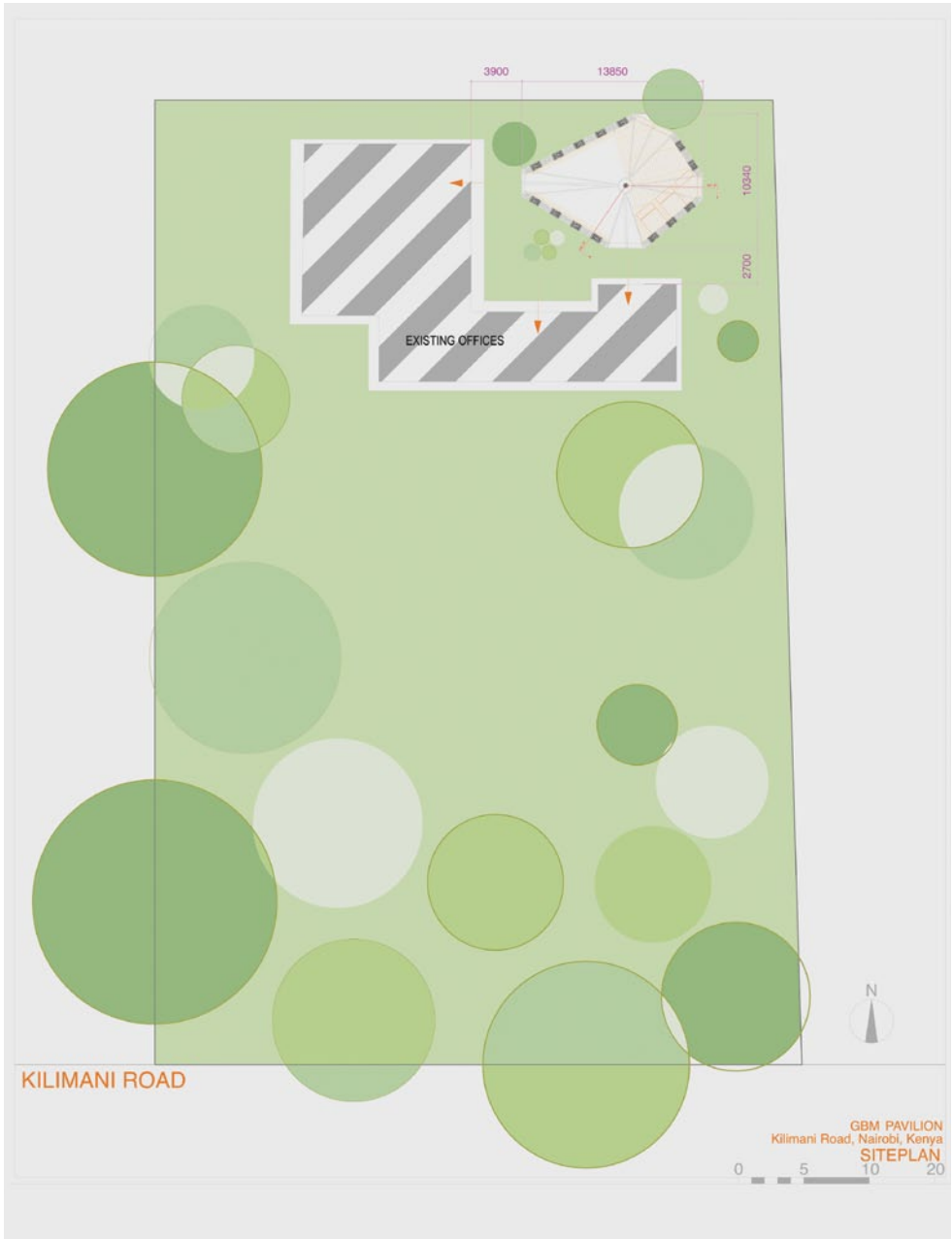
- 1. What is the most sustainable building method for a temporary demountable structure that suits Nairobi's climate, culture and skill base, as well as the limited funds of NGOs?**
- 2. How can the construction process and the building itself be used as tools for teaching, learning and community bonding?**
- 3. What are the variable design possibilities of bamboo as a building material, when using various rope connections?**
- 4. How can the design allow the building to accommodate multiple uses and adapt at different potential sites?**

Methods

- 1. Developing design through responsible and low-carbon footprint practices.**
- 2. Scale modelling and prototyping of the pavilion structure.**
- 3. Material testing research on gumpole wood, softwood and bamboo.**
- 4. A study of existing teaching and learning spaces in Kenya.**
- 5. Trial and error experimental design processes.**

Dissemination

Model exhibited at Turner Contemporary (Margate, June 2013) as part of the RIBA Love Architecture Festival. Paper presented at the Promoting Sustainable Built Environment: Architecture, Landscape, Technology and Society in the Global South conference (Nairobi, Oct 2013). Paper and poster presented at the Creativity, Autonomy and Function conference (Istanbul, Dec 2013).



Introduction

The Green Belt Movement (GBM, www.greenbeltmovement.org) is an NGO working on several reforestation projects throughout Kenya. The organisation requires a ‘learning and meeting space’ for their headquarters, currently based in a converted three-bedroom house with a large garden in a residential neighbourhood of Nairobi. The new pavilion will be located in the garden and offer relief for the cramped conditions of the house. The pavilion should also provide ‘inspiring space’ for meetings and the frequent visits of film teams, local and international officials. [fig. 1–3]

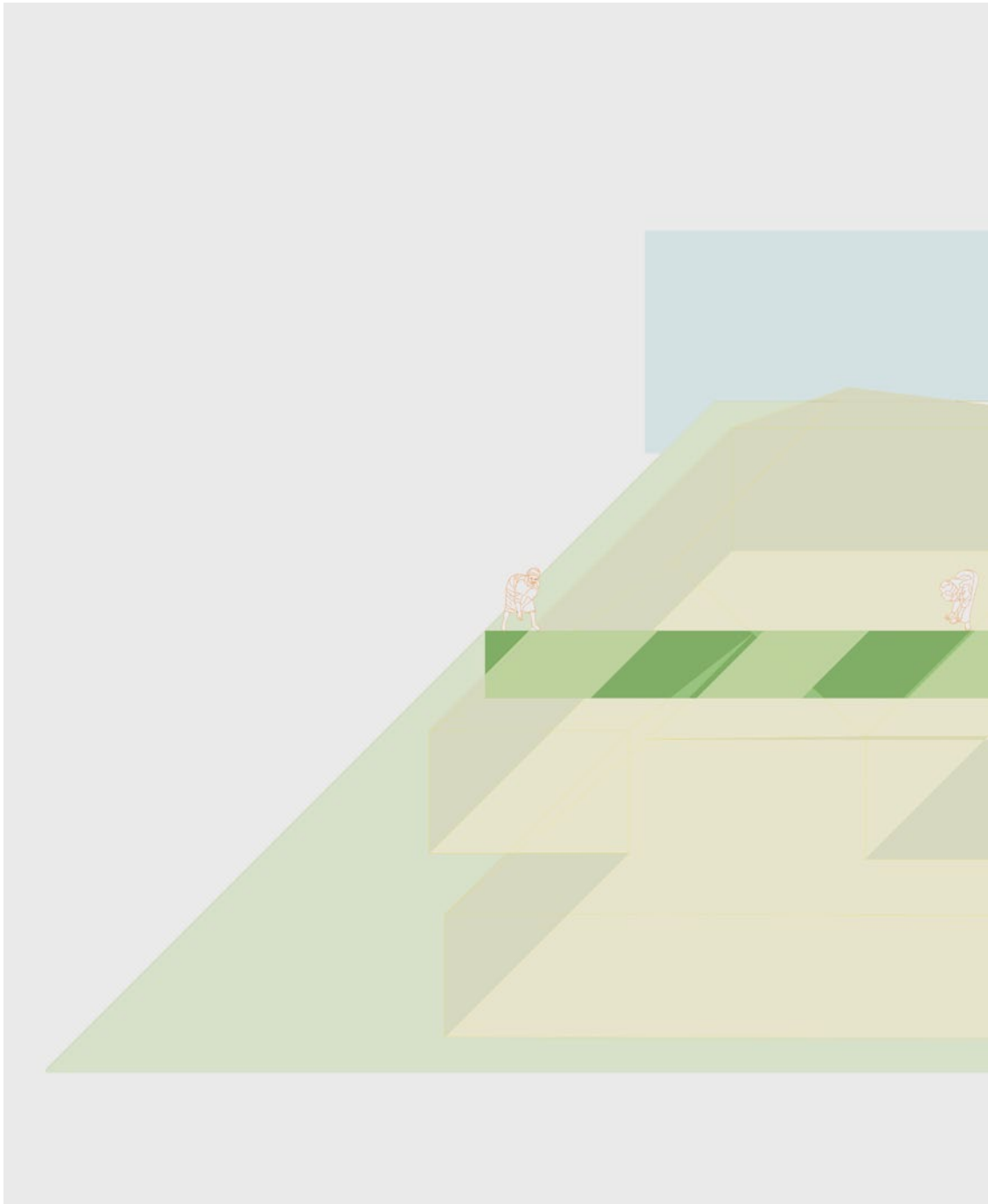
Humanitarian aid initiatives such as the GBM often lack adequate, functional meeting spaces that allow for knowledge transfer and community engagement. This project aims to propose ways of

empowering the community through architecture and, in this way, create a design that advances the GBM’s environmental work.

Adaptability and the use of renewable resources lay at the heart of the project right from the start. The pavilion will be initially installed in the Kilimani Lane garden, to be dismantled and reinstalled at a new site when GBM needs a larger base to cope with increased activities.

The project went through three design and research phases to test different building materials in order to determine the most economic and sustainable solution: the first phase researched local gumpole wood; the second, cheaper softwood; and the third and final version, locally sourced bamboo. [fig. 4]

2
Site plan of GBM headquarters in Kilimani Lane, Nairobi. The new teaching and learning pavilion will sit behind the main building.





GBM PAVILION
Kilimani Road, Nairobi, Kenya
elevation



4

4
Two panoramic
photographs showing
the present situation
of the site behind
the main building.
Top view looking
east, bottom view
looking north

Aims and Objectives

The research aims to devise an economic and simple structural method suitable for building the pavilion, and to ensure that this is an adaptable method that could be repeated elsewhere according to future needs. The significance of the project lies in the introduction of bamboo as a renewable building material and the demonstration of simple joining details to the local community.

A series of building workshops are planned to enable members of the community to build the shelter themselves. By being involved in the production and maintenance of the building, locals would acquire new work skills and preserve local craft techniques, passing this knowledge on to future generations. This manner of building questions the more costly over-engineered alternatives coming from the West.

The project can be seen within the broader context of finding architectural aiding strategies that support citizen

participation. The provision for humanitarian aid in developing countries has been changing over the last decade as both governments and NGOs realise a number of obstacles stand in the way of effective delivery of aid. Goods are often lost through mismanagement and corruption, or through inappropriate delivery (e.g. in the wrong location or at the wrong time). Different organisations sometimes deliver similar support to the same areas, creating an artificial surplus in the aid effort. In the end, aid efforts often fail to make any measurable and lasting impact for the people whom they seek to help. The Humanitarian Policy Group's research report on aid gives a series of recommendations to address these problems (Harmer and Cotterell, 2009). It focuses on the enabling role that governments, NGOs and donors can play, as well as the positive role that citizens can exercise through active participation.

Questions

What is the most sustainable building method for a temporary demountable structure that will suit Nairobi's climate, culture and skill base and the limited funds of NGOs?

Research was carried out to determine the most suitable building method in terms of environmental and economic sustainability, as well as ease of construction, dismantling and reconstruction. An experimental trial-and-error design process involved first the use of local gumpole wood, then the use of cheaper softwood, and finally the use of bamboo poles and rope (see *Methods*).

How can the construction process and the building itself be used as tools for teaching, learning and community bonding?

The GBM pavilion seeks to promote the use of bamboo as a building material, and to involve members of the local community in building the pavilion as a means of enhancing their skills. Such citizen participation helps to strengthen the sense of community among locals, and eventually leads to a more independent approach towards humanitarian aid initiatives related to buildings.

What are the variable design possibilities of bamboo as a building material, when using various rope connections?

Bamboo is an underused building material resource in Kenya. A fast-growing resource, it provides a variety of possible uses, protecting the local trees from being felled. A simple connection can be used to erect structures without the need for lifting equipment. Various connection solutions were researched in detail through drawing and modelling (see *Methods*).

How can the design allow the building to accommodate multiple uses and adapt at different potential sites?

Lack of resources and space constraints mean that single-use buildings are impractical. Taking inspiration from traditional meetings under trees, this project re-creates the logic of gathering around a tree by proposing an architectural structure that is similarly flexible and open to accept multiple uses. The structure is modular and has a variety of adaptable areas and levels to accommodate the different needs of the NGO. The principles of modularity, flexibility and adaptability permit similar structures to be built elsewhere. [fig. 5 & 6]



5



6

5
(Kenya) Typical tree nursery by the GBM, showing the community taking part in reforestation initiatives

By courtesy of Lisa Merton, www.takingrootfilm.com

6
One of the first seven trees the GBM planted by Wangari Mathai in 1977. The tree shows how the space in the shade is used for informal meetings. A platform is built to define the space for meetings to be held.

Context

Humanitarian aid for the environment

The Green Belt Movement (GBM) aims to foster long-lasting cultural change by working at the grassroots level to promote environmental conservation and to empower whole communities by giving them a sustainable livelihood. Since Prof. Wangari Maathai founded the organisation in 1977, the GBM has planted over 51 million trees in Kenya. The trees impede soil erosion, allow the ground water table to stabilise, and provide firewood and building materials. Over 30,000 women have been trained in forestry, food processing, beekeeping and related trades. This process supports local economies, develops new income streams, and deters the migration of the population from rural to urban areas.

Teaching and learning spaces

In 2007 the Aga Khan Foundation together with the Kenya Ministry of Education (MoE) and the United States Agency for International Development (USAID) initiated the 'Whole School Approach' through a programme called EMACK (Educational for Marginalised Children in Kenya). EMACK works to change the delivery of schooling for communities throughout Kenya. Instead of planning schools with little community involvement, it empowers the community to organise the way the schools are formed from a bottom-up direction (USAID, 2011).

It is in this context that this project operates. It aims to create an inspirational 'teaching and learning space' for an NGO which already engages actively with community training. It is designed to be easily adaptable for various uses, and as such acts as a model for other kinds of educational use. Several case studies of educational spaces in the developing world were studied, looking particularly at cultural appropriateness; use of local resources; sustainable approach to building and maintenance; quality of space; and time, cost and the building's lifespan.

Building with bamboo

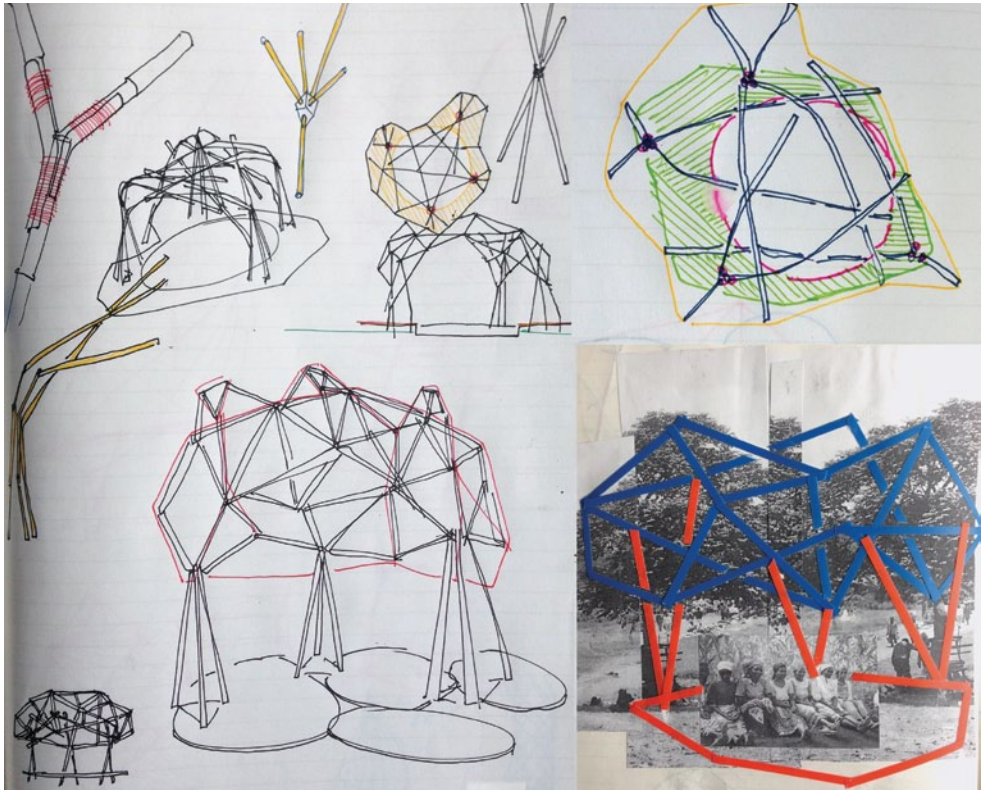
Currently there are approximately 150,000 hectares of bamboo grown in Kenya, but a lot is wasted because there is very little understanding of the actual commercial and environmental value of the product (Njagi 2012).

Expanding bamboo production could help to prevent deforestation and timber usage of the native forests. Bamboo planting can stabilise and protect the soil. It can be grown very quickly (up to 3.5 metres per year) and harvested every three years. The annual harvest can be up to 25 times that of wood. Also bamboo doesn't require expensive machinery to turn it into a usable building material (Kigomo and Brias 2007).



7

7
Typical community meeting under a tree in rural Kenya
Picture source:
www.usaid.gov/kenya



8

8
Initial sketches
exploring ideas
of meeting under a
canopy and ideas for
connections between
the bamboo poles

9
Development
sketches and
models looking
at the meeting
space and different
configurations of
the roof structure



9

Methods

The final proposal describes a pavilion that covers an area of 94m². The space is arranged over three platforms. The first one is a ground level of 45m² surrounded by a bench. The second level is raised by 350mm. This area can be used for more formal meetings and presentations, and is shaded by roll-down blinds or a simple curtain. The last level is at a height of 700mm and has a platform for a speaker, while providing storage space for equipment underneath.

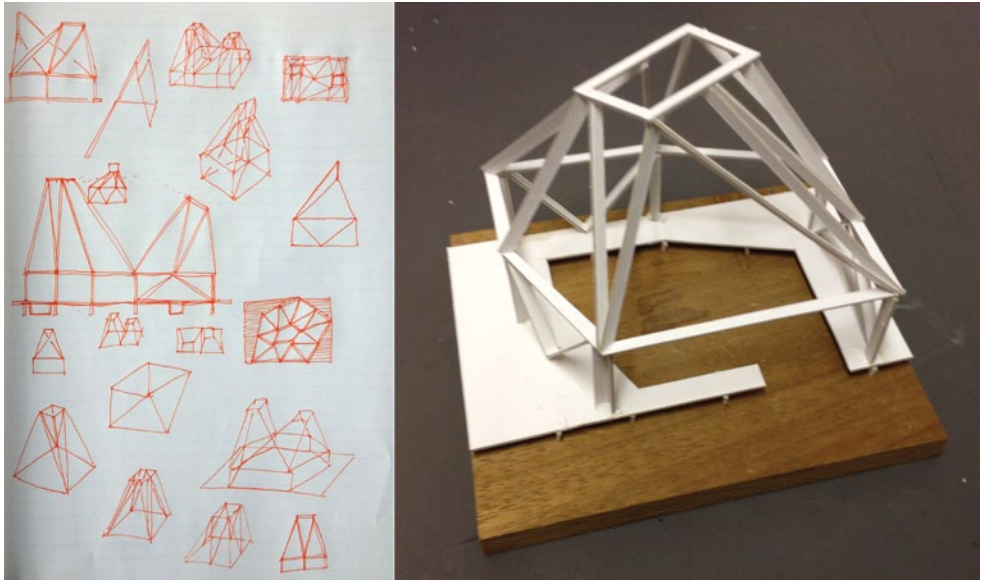
During the design and research process a variety of methods were followed:

1. Developing design through responsible and low-carbon footprint practices;
2. Scale modelling and prototyping of the pavilion structure;
3. Material testing research on gumpole wood, softwood and bamboo;
4. A study of existing teaching and learning spaces in Kenya;
5. Trial and error experimental design processes.

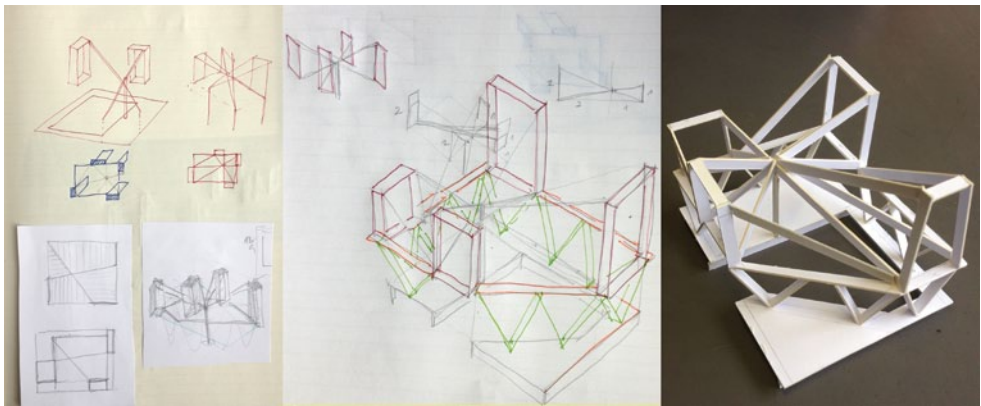
The idea of the tree

Trees are at the heart of the GBM. Trees provide firewood, inhibit soil erosion, protect the ground water table, provide shade and have a moderating effect on the microclimate. They provide habitat for many other plant species and animals, and remove carbon dioxide from the atmosphere. They give a carbon-neutral source of fuel for cooking and building material. For the GBM, trees also have symbolic meaning: they create a social place, the place where the organisation educates locals about conservation and the environment.

The GBM pavilion attempts to embody the image of the tree: it provides basic seating for informal meetings around a central trunk-like column, with branches surrounding it, and a sheltering canopy that allows glimpses of the sky. The roof structure is a folded surface supported by a central column and 14 V-support columns at the perimeter. Erected on dug foundations out of mass concrete, the perimeter columns support a ring beam. Atop the ring beam, four gables let light into the structure. [fig. 7–12]



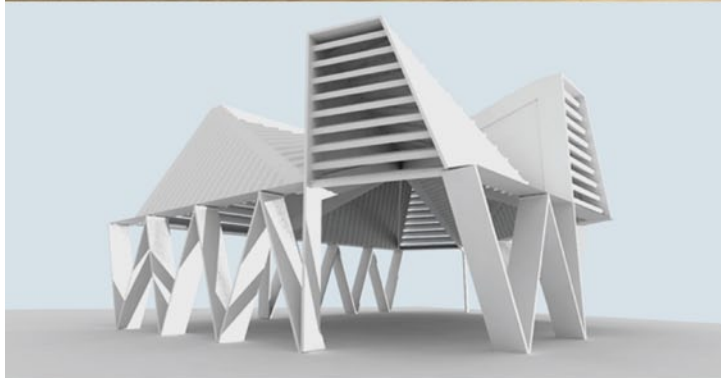
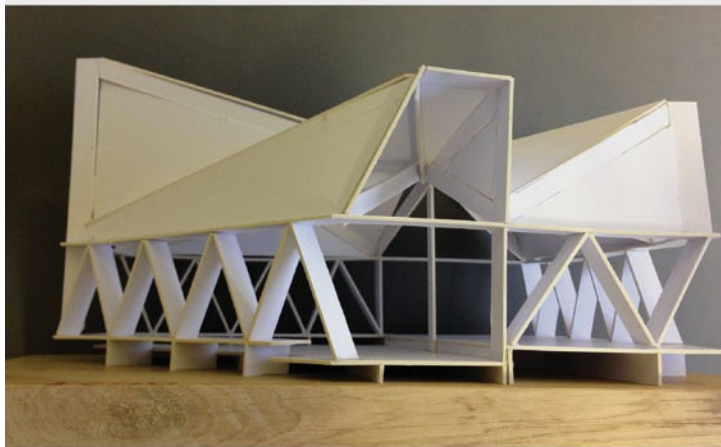
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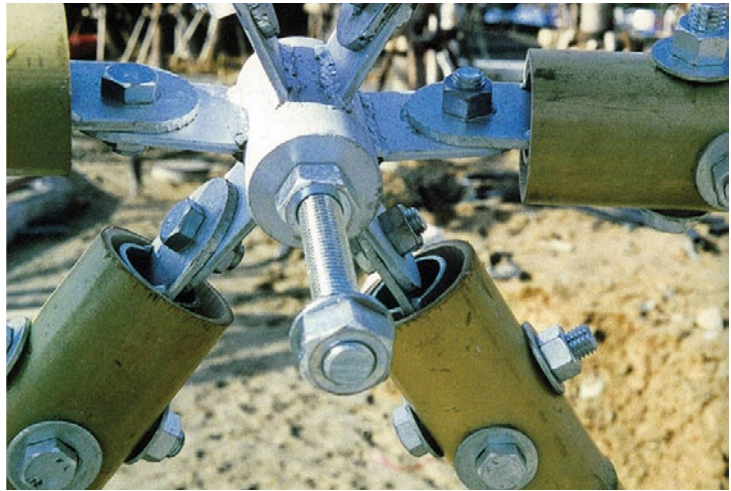


11

10
Development model
and sketches of the
meeting pavilion
designed in softwood

11
Development model
incorporating
different levels
and openings in
the roof to organise
the spaces in
the pavilion





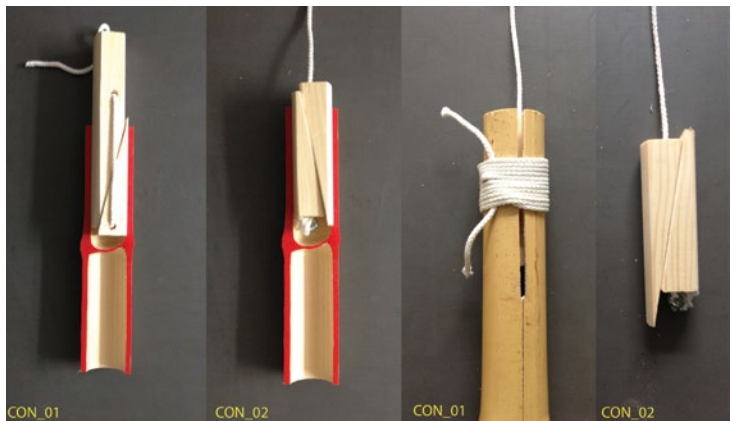
13

13
Shoei Yoh, mechanical bamboo connections for roof structures in Fukuoka, Japan (1989)



14

14
Renzo Piano, bamboo connections for the Renzo Piano Building Workshop (1997)
 © Fondazione Renzo Piano.
 Photograph Fregoso & Basalto



15
First testing of different bamboo connection ends with simple wooden inserts and ropes

15

Bamboo and rope

Although it has high tensile strength, bamboo is very fragile under radial compression. This results in problems when using different joining techniques. There are precedents of successful bamboo joints using inserted metal components but these would lack practical benefit on site, and be costly and inflexible for Kenya. Examples include the bamboo connectors designed by architects Shoei Yoh (1989) and Renzo Piano (1997) in Japan and Italy, respectively. [fig. 13–15, 19 & 20]

Simpler wooden connectors were considered but ultimately rope and lashings connections proved to be the most appropriate. Looking at the Scout Handbooks led to the development of a simple connection using a looped rope and a draw stick. The draw stick enables the connection to be tightened in case the structure moves or the bamboo shrinks. No tools are required to tension or release the connection. No prior knowledge of different knotting techniques is necessary and the draw stick can be added to connections later. When using a draw stick, a loop line is necessary to ensure the tension is spread all across the joint. Each connection is in this way non-permanent and reusable. This joining technique uses the least material and is used all over Asia for large-scale scaffolding on building sites (Hong Kong Architectural Services Department 2012).

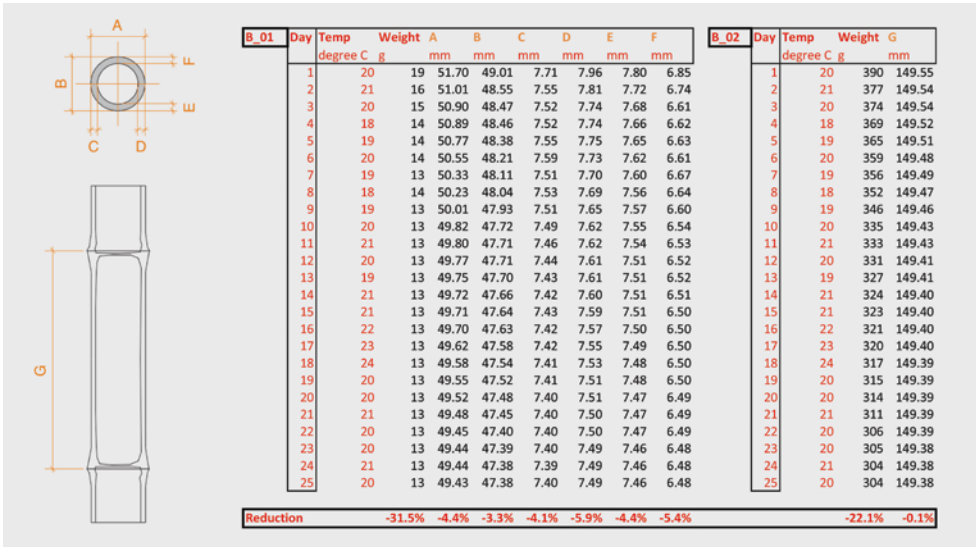
Bamboo is a natural material and as such is affected by heat and humidity. A joint should be adjustable in case the bamboo shrinks when drying out. A series of tests established that the drying process in bamboo reduces the diameter of the

material by approximately 3.3–5.9 per cent over a period of 25 days from the bamboo harvest. Along the length of the bamboo poles the reduction is insignificant (approximately 0.1 per cent). Fluctuations due to climatic conditions on the ground might result in a further change in the size of the materials. Any mechanical connection has to accommodate these changes or the bamboo will split and crack. [fig. 16–18]

For the GBM pavilion there are only three types of connections necessary:

1. A square lashing for regular connections between two poles;
2. A diagonal lashing for rectangular connections between two or more poles with added stability;
3. A shear lashing for connections that need extra tightness by shearing the poles after lashing. [fig. 21–25]

The pavilion uses a variety of bamboo pole sizes of the *Oxytenanthera abyssinica* species, as the most suitable and economical for use in Kenya. The main supports, ring beam, central column and main rafters are 55–70 mm bamboo poles. In the roof thinner bamboo poles of 35–50 mm are used to support the natural roofing material, which is bundled local *makuti* leaves.

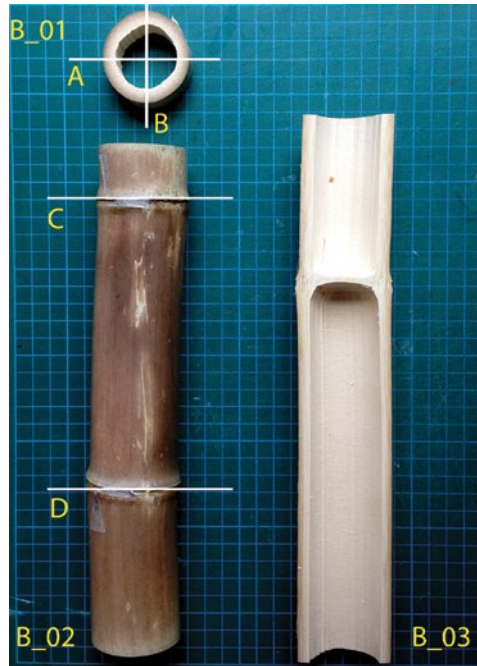


16



17

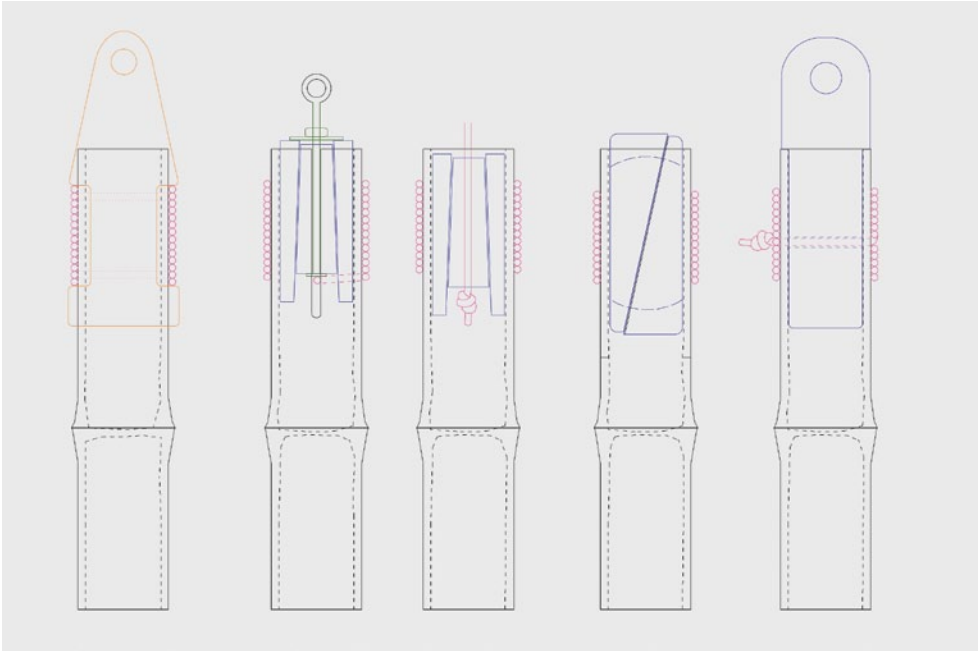
16 Data sheet showing the rate of shrinking during the drying out of the bamboo poles over a period of 25 days



18

18 Key drawing for the testing of the bamboo ends drying and shrinking

17 Visit to the Palm Centre in Kew to harvest bamboo poles for the connections (Mar 2013)



19



20

19
Drawings exploring
different methods
of mechanical inserts
into bamboo poles
for corner joints

20
Bamboo joint with
a loop rope and
a drawing pole for
readjusting the

tension on the joint
during and after the
drying of the bamboo
poles

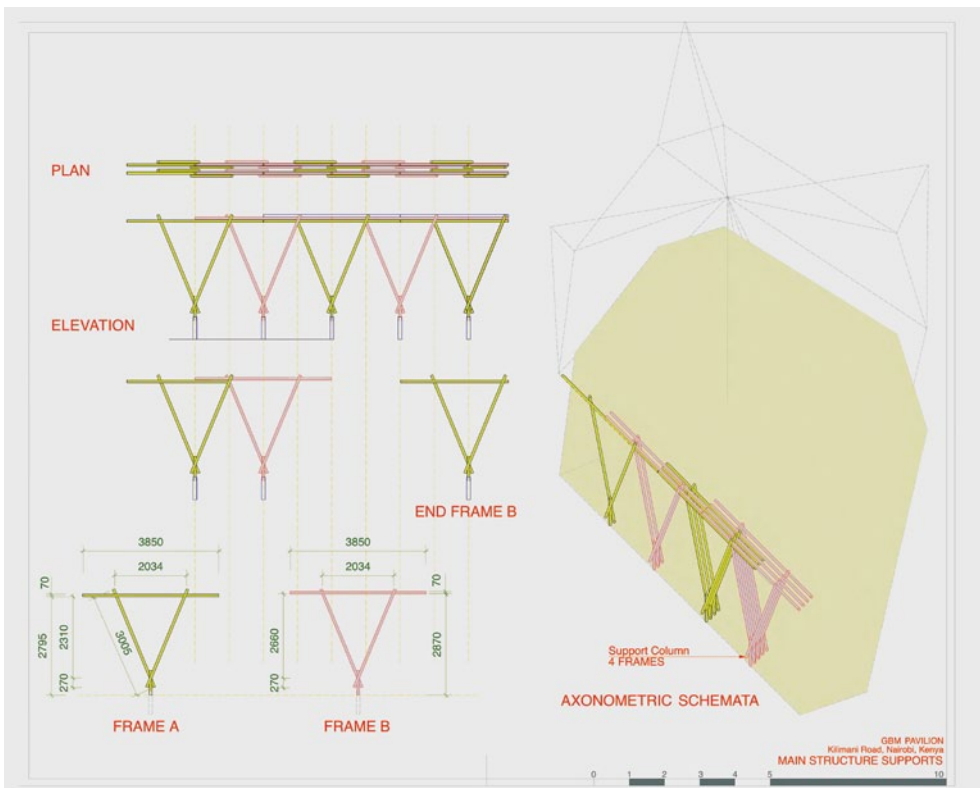


21a



21b

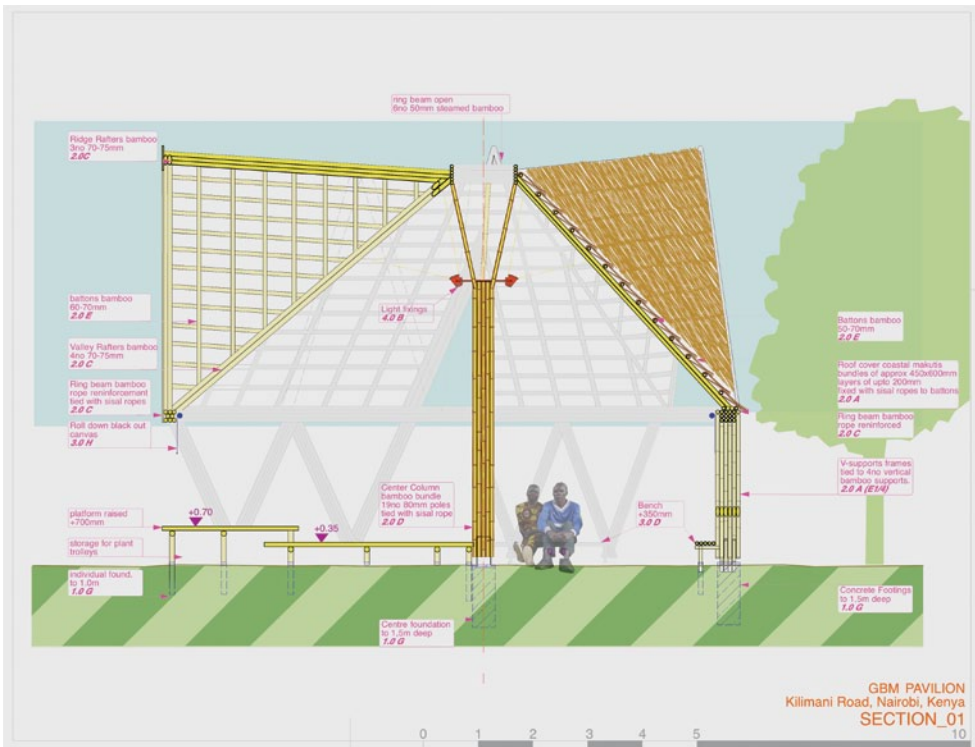
21
Elevations of the final
model of the final
design in softwood







25
Final model of the
GBM pavilion



A key research question has been how the project's methods in realising this demountable bamboo structure can potentially influence the planning of other new small buildings in Kenya. Weber investigated the cultural heritage of bamboo in Kenya alongside the practical and aesthetic benefits and disadvantages of its contemporary use as building material:

Craft heritage: designing a simple structure that has the potential to enhance local craft traditions and technologies.

Environmental impact: using bamboo as a carbon-neutral and quickly renewable material that is easily recycled.

Cost: using locally grown material and simple joints to keep construction costs low.

Construction time: using lightweight and easy to handle materials to ensure a quick building process.

Portability: using non-permanent fixtures so that the structure can be dismantled and relocated.

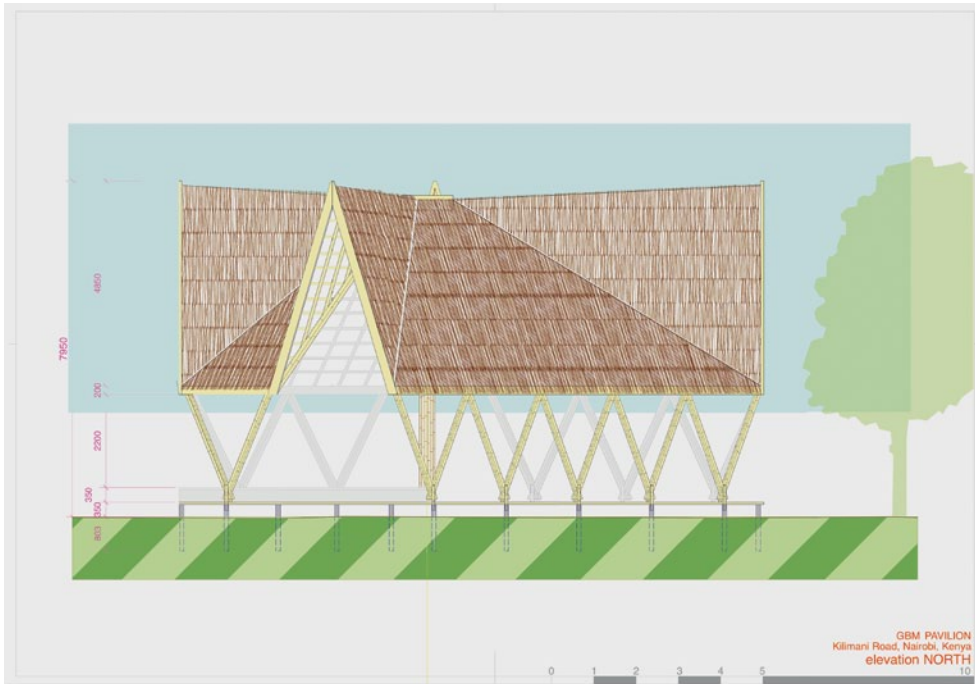
Climatic responsiveness: using natural ventilation through a double layer construction to create a controlled environment.

Knowledge transfer: designing an adaptable bamboo structure to be built by the local community.

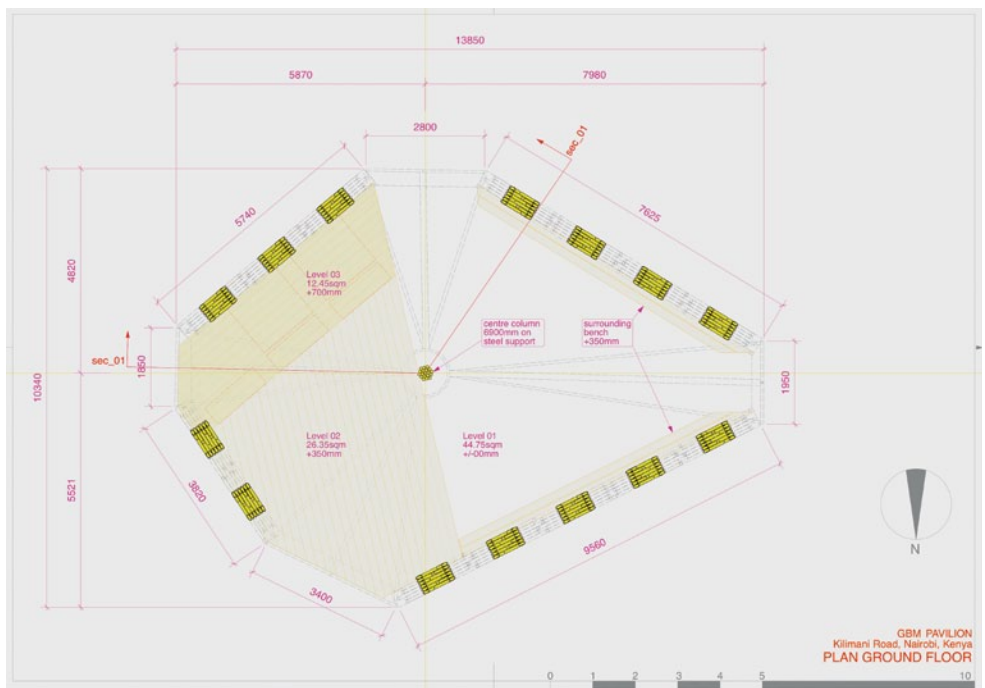
A number of problems encountered when working with bamboo were also considered. Bamboo should be treated against insects; it should be used correctly to avoid rotting; it can be an invasive species, so it must be carefully managed; it can create greater wear on tools. [fig. 26–30]

Design phases

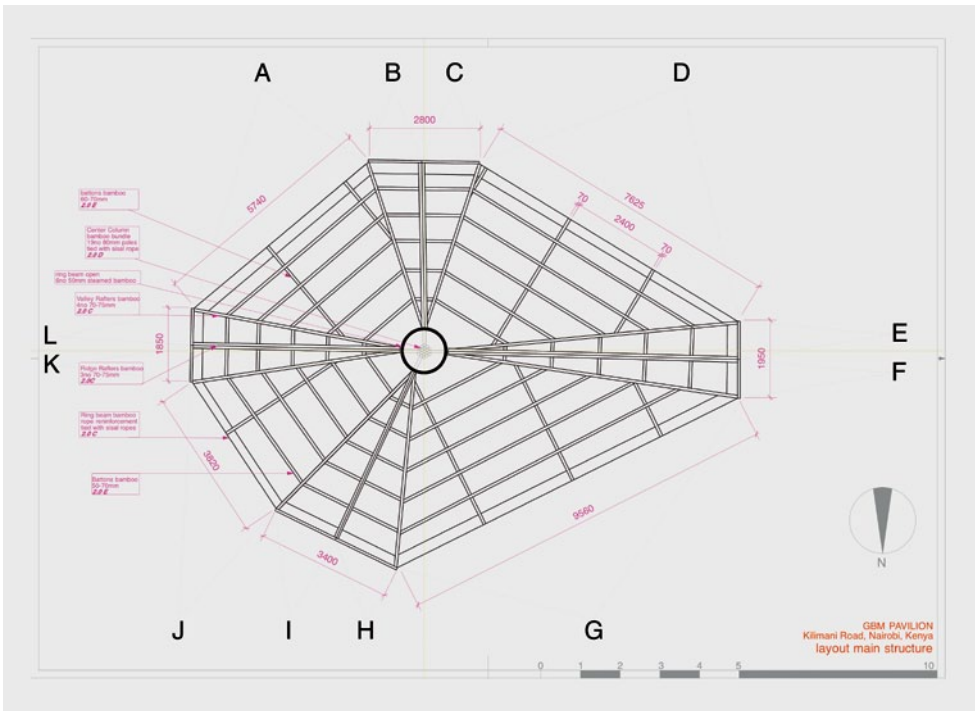
The pavilion design went through a series of phases. Following the ethos of the GBM, a wooden building was initially planned. After several costing exercises by the local architects in Kenya, we realised that relying on locally available woods would make the building too expensive. The cost for the project in gumpole wood came in at a total of US \$56,570.10. An alternative in local sawn softwood came in at a total of US \$39,407.60. We then developed a revised set of plans, sections and details for the bamboo version, with the result that this material was both the least expensive and most sustainable. [fig. 31]

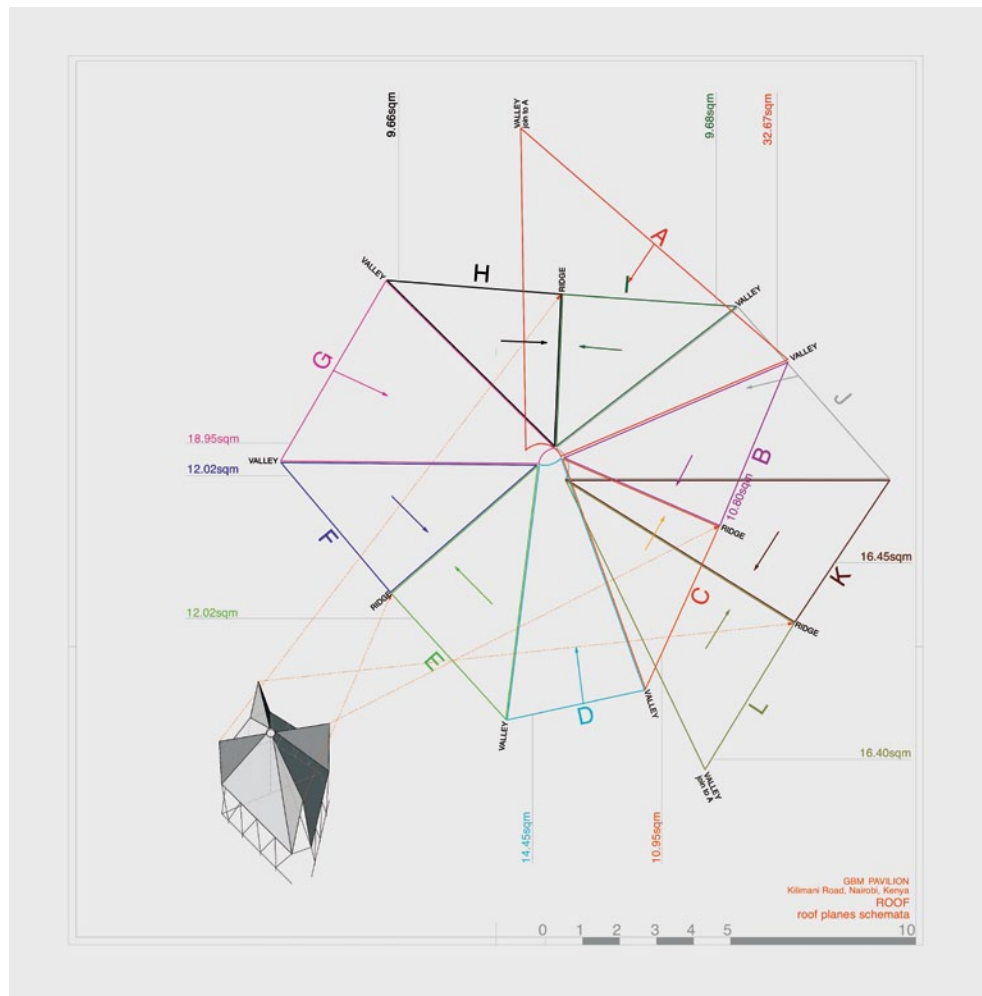


27
Drawing of the north
elevation of the
pavilion on site



28
Plan of the pavilion
showing the three
different levels





30
Drawing showing
the main roof plane
geometry flattened
for costing





31 Final presentation drawing. The drawing (rotated and rejoined) consists of two square tile drawings that can be reconfigured to explore different aspects of the site, the proposed shelter and its possible uses.





33

32 & 33
Views of the
exhibition of the RIBA
Love Architecture
Festival at Turner
Contemporary,
Margate, 2013

Dissemination

Throughout the project Weber has been in discussions with the Green Belt Movement (NGO and client), the Planning Systems Services Ltd, Nairobi (local project architects and quantity surveyors), John McAslan + Partners, London (project initiators) and the Palm Centre Kew Gardens, London (bamboo source and expertise for testing in London).

Exhibition

Exhibited in *Architectural Models*, part of the RIBA Love Architecture Festival, at Turner Contemporary, Margate, 27–30 Jun 2013.

Conference presentation

'Teaching and learning spaces for developing countries'. *Promoting Sustainable Built Environment: Architecture, Landscape, Technology and Society in the Global South (SABS 2013 conference)*, School of Architecture and Building Sciences, Jomo Kenyatta University of Agriculture and Technology, Nairobi, 10–12 Oct 2013.

Poster and paper presentation

'GBM Teaching and Learning Pavilion for Nairobi, Kenya'. *Creativity, Autonomy and Function (ARCHTHEO 2013: Theory of Architecture conference)*, Mimar Sinan Fine Arts University, Istanbul, 4–6 Dec 2013. [fig. 32–34]

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Project: Chichester Pavilion
Architect: Terry O'Rourke Architecture

The Chichester Pavilion scheme is for an outdoor community meeting space and display area. It was originally designed and commissioned for the Royal and General Hospital in Chichester.

The pavilion structure is built using existing timber with a timber cladding to one side which has a single screen, locally sourced, to be positioned over the whole site in order to provide a sheltered area for the pavilion and covered in timber in order to help with the structure.

In the meantime, the pavilion structure has been adapted for use as a temporary storage for a collection of timber and may be built using wood for the cladding. However, the main structure is made of steel and the pavilion structure has been adapted for use as a temporary storage for the pavilion.

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Related publications by the researcher(s)

pp. 41–55

Patrick Weber, 'A teaching and learning spaces for developing countries'. *Promoting Sustainable Built Environment: Architecture, Landscape, Technology and Society in the Global South (SABS 2013 conference)*, School of Architecture and Building Sciences, Jomo Kenyatta University of Agriculture and Technology, Nairobi, 10–12 Oct 2013.

pp. 56–71

1.2. Patrick Weber, 'GBM Teaching and Learning Pavilion for Nairobi, Kenya'. *Creativity, Autonomy and Function (ARCHTHEO 2013: Theory of Architecture conference)*, Mimar Sinan Fine Arts University, Istanbul, 4–6 Dec 2013.

pp. 72–75

Patrick Weber, 'Teaching and Learning Pavilion for Nairobi'. *Architecture in Development* (2 Jun 2013): <http://architectureindevelopment.org/news.php?id=54>

34

**View of the model
exhibited at Turner
Contemporary as
part of the RIBA Love
Architecture Festival,
Margate, 2013**

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Teaching and Learning
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Modulating Light and Views

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