



2010 On Site Review Report

3663.IDA

by Brigitte Shim

Green School

Bali, Indonesia



Architect

PT Bambu / Aldo Landwehr, John Hardy

Client

Yayasan Kul Kul

Design

2006

Completed

2007

Green School*

Bali, Indonesia

I. Introduction

The Green School with its affiliates the Meranggi Foundation and PT Bambu were founded by John and Cynthia Hardy, designers and environmentalists from Bali, Indonesia.

They were both concerned about the depletion of the world's resources and became advocates for the use of bamboo as an alternative to rain forest timber as a building material.

The Green School creates a sustainable campus straddling both sides of the Ayung River in Sibang Kaja, Bali. The campus is situated in a lush jungle with native plants and trees along with sustainable organic gardens. The campus is powered by a number of alternative energy sources including bamboo sawdust hot water and cooking system and a hydro-powered vortex generator and solar panels. Campus buildings include: classrooms, gym, assembly spaces, classrooms, faculty housing, offices, cafes, and bathrooms. On the Green School campus are a range of inspiring architecturally significant spaces from large multi-storey communal spaces to much smaller classroom spaces. Bamboo is a local sustainable material used in innovative and experimental ways demonstrating its architectural possibilities. The result is a holistic green community with a strong educational mandate that seeks to inspire students to be more curious, more engaged and more passionate about our environment and our planet.

The Meranggi Foundation is an initiative to develop plantations of bamboo plants embedded in the local agrarian community through gifting bamboo seedlings to local rice farmers along with advice from bamboo experts about where to plant their plants. This environmental non-profit organization raises bamboo seedlings in their nursery and distributes them to farmers across the island of Bali helping them grow commercially valuable bamboo species. The Foundation maintains detailed planting records using GPS technology, monitors bamboo growth rates (including associated carbon capture) as well as securing markets for future bamboo trade. To date, the Meranggi Foundation has distributed over 60,000 bamboo seedlings, sharing their skills and expertise with locals to help grow and harvest high quality bamboo. In a few years time, the work of the Meranggi Foundation will generate enough bamboo for a growing sustainable construction industry and to supplement the income of local farmers.

PT Bambu is a for profit design and construction company that promotes the use of bamboo as a primary building material to avoid further depletion of our rain forests. The Green School campus is a giant laboratory built by PT Bambu demonstrating innovative uses of bamboo for a variety of building scales and programmatic types.

II. Contextual Information

A. *Brief Historical Background*

Founders of the Green School are two expatriates' John and Cynthia Hardy who have lived in Bali for decades and were committed to giving back to a country that had been so good to them. John Hardy was born in Canada and travelled to Bali in 1975. Intrigued by Balinese craft traditions, he settled there and began producing jewellery with local artisans. Cynthia Hardy was born in America and arrived in Bali in 1982. John and Cynthia Hardy began their professional collaboration as the founders of an internationally respected jewellery company in 1989. In 2007, they decided to found an independent school on the island of Bali giving back to a place that had been so good to them.

'We are building Green School to create a new paradigm for learning. We want children to cultivate physical sensibilities that will enable them to adapt and be capable in the world. We want children to develop spiritual awareness and emotional intuition, and to encourage them to be in awe of life's possibilities.' (John and Cynthia Hardy)

B. *Local Architectural Character, including Prevalent Forms and Materials*

The traditional Balinese house is usually a compound housing two or three generations of the same family in a village grouping called a *banjar*. Each compound is a microcosm of the universe with realms for the gods, man, and the impure spirits. Balinese homes are not architect designed, rather villagers build their own homes, or a community will pool their resources for a structure built under the direction of a master builder and/or a carpenter. The norm is a post and beam structural system with either wood or bamboo non-load bearing infill panels. Traditionally, rather than nails, mortis and tenon joints and wooden pegs are used. The roofs are a thatch material that can be made of coconut or sugar palm leaves, *alang alang* grass or rice straw.

The Green School buildings fully understand and respect the traditional vernacular architecture of the region and uses design creativity to go beyond to create modern spaces using traditional materials.

C. *Climatic Conditions*

Lying along the equator, Bali has a tropical climate, with two distinct monsoonal wet and dry seasons. Average annual rainfall in the lowlands varies from 70-125 inches. Humidity is generally high, averaging about 80%. Temperatures vary little throughout the year; the average daily temperature range on the island of Bali is 26-30 °C (79-86 °F). The Green School site is located at Latitude -8.548 and Longitude 115.136.

D. *Immediate Surroundings of the Site*

In central and southern of Bali the land descends to form an alluvial plain, watered by shallow, north-south flowing rivers, drier in the dry season and overflowing during periods of heavy

rain. The longest of these rivers, the Ayung River, flows approximately 75 km through central Bali.

Due to human influence, many we consider native to Bali have been introduced by humans within the last centuries, making it sometimes hard to distinguish what plants are really native. The most common larger trees are: banyan trees, jackfruit, coconuts, and bamboo species. The landscape is also populated with Acadia trees and many varieties of bananas plants. Numerous flowers can be seen such as hibiscus, frangipani, bougainvillea, poinsettia, oleander, jasmine, roses, begonias, orchids and hydrangeas. Rice comes in many local varieties. Other plants with agricultural value include: salak, mangosteen, corn, coffee and water spinach.

E. Topography of the Project Site

The site for the Green School straddles both sides of the Ayung River in central Bali on an undeveloped piece of land. The Green School campus abuts seven hamlets or local *banjars*. There is a 70 metre vertical drop from the table land on both sides down to the level of the Ayung River on a site that contains farmland, jungle, mountain sides and a river.

III. Programme

A. History of the Inception of the Project

In 2007, John and Cynthia Hardy's decided to start a new school shaping both its educational curriculum and its built form. The Green School is the result of a lot of trial and error, hard work and a deep commitment to create an integrated vision for a sustainable campus. The scope of this endeavor grew organically, expanding from a school to a bamboo nursery to a bamboo factory. The site started off on one side of the river and then land was acquired on the other side of the river necessitating a bridge linking the site and future campus.

B. How were the Architects and Specialists chosen?

A multi-disciplinary integrated design team was needed to realize the Hardy's vision for The Green School. Building a team to tackle the enormous challenges associated with creating a sustainable campus and a sustainable curriculum was not easy. There were many areas of this ambitious project that needed to be researched, designed and implemented and differing skill levels.

Designers and specialists were selected because of their commitment to sustainability as well as their ability to think in innovative and non-traditional ways. The traditional definitions of client, architect, consultant was blurred and reconsidered in the design process for the Green School.

Architects, graduate architects, jewellery designers, sculptors, structural engineers, bamboo experts, master builders worked together in a variety of ways to realize the Green School's Kul-Kul campus. John Hardy was an essential member of the Green School design team as well as the school's patron and client.

C. *General Programme Objectives*

The objective of this project was to create a place for educating young people to become the environmental leaders of the next generation. The physical surroundings for the school needed to express a sustainable design philosophy. It was determined by the school's founders that the school could be a place for invention and experimentation with bamboo which is a locally available material in this equatorial climatic zone.

D. *Functional Requirements*

The design team's brief includes site infrastructure as well as buildings to accommodate the school program.

Site infrastructure including pathways, landscaping, alternative energy power sources, bridges, parking areas, service zones

Functional program includes: Drop off pavilions; classrooms for children from Kindergarten to Grade 9; main assembly building providing multipurpose spaces for teaching, display, gathering, offices; gymnasium; *Mepantigan* area for Balinese martial arts; faculty housing; principal's office; staff room; medical station; cafe or *warung*; composting toilets and change rooms.

IV. **Description**

A. *Building Data*

- Total site area 103,142.63 square metres
- Ground floor area 5,534 square metres
- Total combined floor area (ground floor and upper floors) 7,542 square metres

B. *Evolution of Design Concepts*

Response to Physical Constraints - Siting, Climate, Plot Ratios, etc.

The Green School is located on both sides of the Ayung River. Their sustainable approach to both campus planning and campus building requires greater attention to site infrastructure and its integration into the physical site. At the Green School, bridges, pathways and steps traverse the steep hillside linking various parts of the school programme.

Every day, hundreds of Balinese use the new bridge to get to their temple, rice fields, work or school. It has become a piece of local infrastructure used by the students, teachers and parents along with the broader local community.

Response to User Requirements

The Green School campus is a giant laboratory experimenting with innovative ways to address sustainability. The design team started with faculty housing and moved up in scale to the most

public buildings on the campus. Each building completed provided lessons learned through the design and realization that created greater confidence to take on new challenges.

Purely Formal Aspects

On the Green School campus there are many buildings. Their massing relates directly to their programmatic use and their campus siting. In each building the bamboo structure is exposed, expressed and celebrated. There are many generous roofs and very few walls and windows. The large roof overhangs protect the spaces from driving rains and hot sun. The roofs are covered with *alang alang* which is a local material used for vernacular domestic buildings. Most Balinese temples and sacred spaces are also clad in *alang alang* which is closely cropped like a sharp haircut. At the Green School, all of the buildings covered in *alang alang* that are kept looser at the edges of the roof and not trimmed.

Landscaping

Landscape plays a major role in the Green School campus. Green school classrooms are located on the western ridge of the campus sited around a series of are sustainable gardens with Balinese rice and local vegetables which are tended by the school children and staff. Students circulate through the gardens promoting interaction of all year levels whilst plant varieties are named for children to learn about botany, biology and cultivation. Every garden has its own cycle and one is observing seedlings, mature plants and freshly picked gardens throughout the site.

There are some areas with large open surfaces for playing sports near the gym and heart of school. There is a large mud pit for Balinese mud wrestling located near the Mepantigan studio.

C. *Structure, Materials, Technology*

Structural Systems

Throughout the island of Bali and the country of Indonesia bamboo grows everywhere. It is widely used for temporary structures such as communal festivities and religious events. The understanding of and use of bamboo exists but only for temporary buildings or structures and it is not considered as a material for permanent buildings.

On the Green School campus, bamboo is used in structurally innovative ways to create original and inspiring architectural spaces. Throughout Southeast Asia, China and Japan bamboo is used for flooring, for decorative screens and other non structural applications. In some cases, bamboo is used as a wood substitute through bamboo trusses or bamboo glue-lam beams similar to engineered wood products sold in North America. These applications while using bamboo are traditional and conventional in their structural use of the material. Built examples using structural bamboo are typically orthogonal with regular rectilinear shapes.

At the Green School's public buildings - Heart of School, the gym, bridge, and the Mepantigan bamboo is used to create large assembly spaces for gathering. Each building is a

different experiment in bamboo structures. Bamboo is used vertically as a cluster of columns and also creating a long span arch. *Petung* bamboo, *Dendrocalamus asper*, is adopted as the primary structure forming 3 interlocking trusses dissecting the triangular plan. The structural loading of the trusses are transferred to foundation through a traditional structural column type known as *dupit*.

The primary structure is anchored to the foundations by an innovative method of lacing river rocks and bamboo with reinforced steel connected to the concrete foundations. The bamboo connection to ground plane is tapped and filled with cement creating a solid structural connection for wind loading.

The secondary structure and rafter elements are lighter weight Bamboo *Tali*, *Gigantochloa Apus*. The rafters are installed at 300 mm centers fixed to the primary bamboo *Petung* with bamboo pins.

Alang alang or Balinese grass strip tiles are overlapped and individually tied to form the roofing surface adding additional bracing and strength to the structural components. The 3 interlocking trusses form breaks in the roof plane which is covered by canvas forming skylights.

Materials

- Structural Members

At Heart of School, groupings of bamboo columns 16 – 18 meters high provide the structural mass for the soaring three storey high spaces. Throughout this building there are many bamboo joints that were tested at a 1:1 scale in structural testing labs.

The Gymnasium is a multipurpose facility for physical activities and gathering. Technically demanding structural bamboo arches are used providing an 18 metre column free span and height of 14 metres.

The Metapantigan Studio is multipurpose facility for theatre, social events and gatherings. The strength and stability of the structure relies on four main arches. Each arch consists of three *petung* bamboos providing another column free span. Stepped seating is integrated into the base of the building.

Kul Kul Bridge is a bamboo suspension bridge connecting both sides of the Ayung River. The bridge has a span of 20 metres and a width of 2 metres. Empirically, this bridge has tested to subject 6 ton load.

- Infill Materials

The main assembly buildings on the Green School campus do not have any walls or doors. Some of the offices, staff rooms and faculty housing use bamboo infill panels and single glazing to create enclosure. Within The Green School classrooms, canvas impregnated with natural latex is used to create intimate bubble spaces for gathering.

- Renderings and Finishes

Alang alang thatching has been used in Indonesia for hundreds of years and on the island of Bali it is the traditional system of roofing

The blades of *alang alang* thatching are constructed from the *Grass Imperata Cylindrica* which is locally called *ambongan*. It is also called *alang* in Indonesian and Malay. It is a tough and resilient grass and grows best in harsh conditions and poor ground.

Construction Technology

The building of the Green School campus relies on local craftsmen and artisans to realize the numerous building types. Bamboo is used not only for the finished building but as the scaffolding and intermediary armature for construction. Low tech equipment and ingenuity are used to build large scale, complex spatial volumes without the benefit of heavy equipment or cranes.

The Green School design team worked directly with Professor Ir. Morisco, a world leader in structural properties of bamboo leading the Structural Engineering Laboratory in the Department of Civil and Environmental Engineering at Gadjah Mada University in Yogyakarta. His colleagues Ashar Saputra and Inggar Irawati working under Professor Morisco formed the structural engineering team for this project.

The design team prepared detailed construction models and brought them to the Structural Engineering laboratory. The engineering team took the physical model and transformed it into a computer model. It took them over two months to prepare accurate computer models of all of the Green School buildings.

Through the computer models the structural engineering team was able to test the axial loading, wind and uploading, earthquake loads to ensure compliance with the Indonesian building codes. The types of buildings designed for the Green School were very irregular and there was very little precedent for methodologies and precedents for analysis.

Building Services, Site Utilities

A local volcanic stone provides permeable paving all of the pedestrian pathways and parking areas on the Green School campus. Domestic hot water heaters are fuelled by bamboo sawdust and rice husks. A vortex hydroelectric plant diverts water from the Ayung River and creates a vortex which can be tapped to create hydro-electricity. This environmentally friendly technology is in its early stages of development. Composting toilets are used throughout the Green School campus.

Bamboo sawdust remnants from PT Bambu's factory and rice husks are used to fuel hot water heaters and kitchens. A vortex hydroelectric plant diverts water from the Ayung River and creates a vortex which can be tapped to create hydro-electricity.

Solar panels are also located on campus. The Green School's composting toilets preserve human waste and use to create bio-gas and compost. All liquid waste passes through a system

which directs the liquid through a gravel chamber where it is filtered by feeding plants and later used for irrigation of crops. Green School garbage is sorted and segregated. Metal and plastics is recycled and organics are composted.

D. *Origin of Technology, Materials, Labour Force, Professionals*

Technology

The Green School buildings rely on local master builders who work with bamboo on a daily basis to realize the remarkable architectural spaces on the campus. The craftsmen who install the *alang alang* roofs understand how to install this primitive technology helping to create modern spaces. All buildings on the Green School campus were built with bamboo scaffolding and basic tools. No heavy equipment or cranes were used.

Materials

Bamboo is believed to be the fastest-growing plant on the planet and is considered to be one of our most sustainable resources. At the Green School this traditional material is used to create modern organic spaces. The Green School's goal is to use between 99-100% natural materials in all construction projects and to recycle as many materials as possible and to manage its waste in a responsible manner. All materials incorporated are locally available materials and simple construction techniques that address prevailing climatic conditions.

Indonesian bamboo is used throughout the Green School campus. Bamboo is believed to be the fastest-growing plant on the planet and is considered to be one of our most sustainable resources. At the Green School this traditional material is used to create modern organic spaces.

Local mud mixed with 15% cement is used for all floors on the campus. Bamboo structural columns are selected from local bamboo lengths.

Bamboo flooring is widely used on the Green School campus for upper floors of buildings like the Heart of School. These floors are 100% bamboo planed and pinned together with bamboo pins using no glue or chemical finishes.

Labour Force

The builders of the numerous buildings on the Green School campus are all local Balinese artisans and craftsmen. The building team have an innate understanding of how to construct with bamboo and worked closely with the multidisciplinary design team to realize a campus full of unique and unconventional buildings.

Professionals

Principal Designers: Aldo Landwehr (deceased) and John Hardy
Architects: Cheong Yew Kuan, Effan Adhiwira, Miya Buxton, Hanno Burtscher, Philip Beck

Structural Engineers: Professor Ir. Morisco Ph.D, Ashar Sapura Ph.D, Inggar S. Irawati
Bamboo Consultant: Jorg Stamm
Project Manager: Ketut Indra Saputra

V. Construction Schedule and Costs

A. *History of Project Design and Implementation*

- 1996 Hardy House in Sayan, Bali. Cheong Yew Kuan was commissioned by John and Cynthia Hardy to design a house overlooking the *Ayung* River. Massive adobe walls define the site and protect a two storey house with an open living platform. Natural logs create large wooden portals on the ground floor that support a second floor tree house.
- 2003 Kapal Bambu, Badung, Bali. Cheong Yew Kuan was commissioned by John and Cynthia Hardy to design a jewellery showroom using bamboo as the primary building material. The soaring 42 foot high space is inspired by a traditional Balinese *watilan* or community hall. Bamboo is the primary structural material and the building is clad in *alang alang*.
- 2005 Tiga Gunung, Badung, Bali. John Hardy, Aldo Landwehr and Jorg Stamm collaborated on the design of a large work space featuring three spiralling central bamboo columns. This cluster of bamboo columns impacts the interior space by providing light through their hollow openings and creates the illusion of three peaks on the exterior. Mud walls form the perimeter and on exterior the building clad in *alang alang* resembles a mountain range.
- 2005 The Long Barn, Baung, Bali. Ketut Indra Saputra built a 56 m long bamboo barn featuring a stairway that can be winched up.
- 2006 Sumatra House, Baung, Bali. Miya Buxton collaborated with John Hardy to build a traditional *Minangkabau* House or big house found in the highlands of West Sumatra. The traditional *Minang* houses are made of wood with a bamboo roof. The Sumatra House is entirely made from an extremely rare black bamboo native to Java. Traditional Columbian binding and pinning joinery eliminated the need for nails and bolts. The footings were built on top of river boulders.
- 2006 Master Plan for Green School Campus. Cheong Yew Kuan was asked to design the campus master plan. He located all the key buildings and open spaces, bridge placement and classrooms.

PT Bambu opens.

The Green School hires director and faculty in preparation for a September 2008 opening.

2007 PT Bambu Kitchen, Badung, Bali. Aldo Landwehr, John Hardy, Yulianto Maliang, Miya Buxton. The kitchen prototype for Heart of School. This experimental project is a gathering place for the creative designers, bamboo factory works and field staff to gather at lunch time. The kitchen staff prepares meals on stovetops fuelled by bamboo shavings and husks from the nearby factory. The space is furnished with bamboo tables and chairs and provides views over the rice and vegetable fields.

Kul Kul Bridge, Green School Campus. Aldo Landwehr, John Hardy and Jorg Stamm, Yulianto Maliang collaborated on the design for the bridge. Jorg Stamm is an internationally recognized designer and master builder of large bamboo structures, buildings, and bridges. He is based in Candelaria, Columbia where he founded the company Eco Bamboo.

Classrooms and Teacher's Housing, Green School Campus. Aldo Landwehr, John Hardy, Effan Adhiwira, Yulianto Maliang. Six classrooms for school children and Nine individual houses for teachers were designed and built. A variety of forms were realized for these two smaller building types.

Mepantigan Dome, Green School Campus. Cheong Yew Kuan, Miya Buxton, Yulianto Maliang. Three levels earthen brick stepped amphitheatre seating provides an earthbound base to a majestic 35 metre span assembly space with a semi-transparent centre bringing light into the space. Used for performances, gathering and assembly.

Hydro-powered vortex generator, Green School Campus. Frank Zotela. Innovative alternative energy system using water from the Ayung River to create hydro power.

2008 Heart of School, Green School Campus. Aldo Landwehr, John Hardy, Effan Adhiwira, Yulianto Maliang, Phillip Beck, Jorg Stamm. The Heart of School consists of three spiraling roof forms that are interconnected to creating remarkable inspiring space for gathering, classrooms, offices, receptions. Students and faculty pass through this building as they move through the campus.

Additional classrooms, bales, staff room, principal's office. Green School Campus. Effan Adhiwira, Yulianto Maliang. Buildings needed to accommodate Green School program.

Design bamboo furniture for school. Chairs, desks, shelving, shoe storage.

Renewable energy solutions. Implemented.

The Meranggi Project. Nursery established and employees hired.

The Green School opens.

2009 Gymnasium. Green School Campus. Ketut Indra Saputra. The gym is a large multi-use space for gathering, physical activities and assembly with an 18 metre column free span, 14 metres high created by a series of bamboo arches.

Warung / cafe. Green School Campus.

B. Total Costs and Main Sources of Financing

	Amount in Local Currency	Amount in US dollars	Exchange Rate	Date
A. Total Initial Budget	58,170,000,000.00	6,000,000	9695	Sep 30 2009
B. Cost of Land	14,542,500,000.00	1,500,00	9695	Sep 30 2009
C. Analysis of Actual Costs				
1. Infrastructure	8,420,921,880.00	868,584	9695	Sep 30 2009
2. Labour	12,788,790,840.00	1,319,112	9695	Sep 30 2009
3. Materials	6,287,672,860.00	648,548	9695	Sep 30 2009
4. Landscaping	1,114,925,000.00	115,000	9695	Sep 30 2009
5. Professional Fees	1,454,250,000.00	150,000	9695	Sep 30 2009
6. Other	146,132,735.00	15,073	9695	Sep 30 2009
D. Total Actual Costs (without land)	30,212,703,010.00	3,116,318	9695	Sep 30 2009
E. Actual Cost (per sq. meter)	3,635,625.00	375	9695	

C. Qualitative Analysis of Costs

Actual Cost: USD 375 per square foot

D. Maintenance Costs

There are no mechanical systems at the Green School.
Natural ventilation is used for all buildings on the campus.

E. Ongoing Costs and “Life Performance” of Building

Alang alang roofing has a 6 - 10 year replacement cycle. The material is available locally and the craftsmen installing the material are also local.

Bamboo has a 20 years life cycle based on conservative estimates. Selective replacement is anticipated.

VI. Technical Assessment

A. *Functional Assessment*

The Green School buildings provide PT Bambu with an excellent array of types of installations and they allow them to monitor their building performance for the next few decades allowing them to make modifications based on performance.

B. *Climatic performance*

The open perimeter walls and central skylight in the main buildings at The Green School allows ample natural and diffused daylight to enter the building, allowing efficient lighting for teaching needs and eliminating the need for artificial lighting during day light hours. Additional low energy lighting is incorporated for after hour needs, powered by renewable energy such as solar panels.

The combination of open walls and semi-detached skylight also allows passive cross ventilation and natural upward draft to vent and cool the building. For the hottest days the central 'bubble' which is a canvas cocoon coated with natural latex is fed by a huge fan cooling the students through the peak mid-day sun.

The thermal mass of the Alang-alang grass roof protects the students from direct thermal gain as well as acting as sound absorption for acoustic comfort. The black board and storage units act as partitions and screens adding additional acoustic protection from and to adjacent classrooms.

C. *Response to Treatment of Water and Rainfall*

The large roof forms all have generous overhangs provide additional protection during wet season rains. All pathways for either vehicles or pedestrians use a local volcanic rock and are permeable. Steep hillside drains water to the Ayung River. Bamboo water channels are used to direct flow.

D. *Environmental Response*

The Green School campus is blanketed by an organic permaculture system design by international and local experts. The School's gardens grow over thirty varieties of rice, fruits and vegetables. Fertile land, a quick growing cycle provides visible farming results feeding the school children, faculty and PT Bambu staff. The organic farming connects the students directly to the land forming the basis of an experiential learning component of the school curriculum.

E. *Choice of Materials, Level of Technology*

Green school strives to use alternative technologies to ensure the campus is as energy independent as possible. Experimentation with sustainable renewable energy solutions extends to; micro-hydro power generation, solar panels and a bio gasification unit that uses bamboo

sawdust, rice husks and other organic materials to produce energy for heating hot water and cooking.

Through the use of skylights and passive ventilation and cooling, energy intensive artificial lighting and climate control systems are virtually redundant. Each student is issued with a laptop computer, powered by renewable energy, further illustrating Green schools commitment to 21st century education beneath an environmental umbrella.

F. Response to, and Planning for, Emergency Situations

The Green School campus is located on the table land and hillside on both sides of the Ayung River and is protected from any major flooding because of the steep vertical elevation between the river and the school buildings. The Ayung River also provides a readily available and accessible water supply in case of fire.

Indonesia is an earthquake prone zone and bamboo buildings provide a positive alternative to traditional building practices. The buildings designed at the Green School use clusters of bamboo columns or long span bamboo arches as their structural approach which are lightweight and respond well to the tremours associated with earthquakes. The school buildings have no doors or windows and access to the exterior is immediate and direct. PT Bambu have plans to add a slide from the upper levels of their largest buildings providing even easier exiting. The big tropical umbrellas of the larger Green School buildings are susceptible to high wind uplift and the structural systems have to take this into account providing appropriate anchorage and resistance.

G. Ageing and Maintenance Problems

The Green School is located in a tropical climatic zone at equatorial latitude. Bamboo has many positive qualities but it is also susceptible to humidity, insects and mould. All structural bamboo used at the Green School is extensively treated using an organic Borax compound. The bamboo is cleaned and then submerged in a Borax bath for a period of 4-6 weeks to ensure resistance to insects. An environmentally friendly waterproof coating is sprayed on the bamboo members to prevent moisture penetration. The buildings on the Green School campus are very open and any humidity build-up can also dry out easily. Ensuring that there are no areas for moisture to build up is essential. The visual examinations carried out by leading structural engineers reviewing key structural joints throughout the campus will ensure a proactive approach to maintenance.

H. Design Features

The Green School campus contains a range of inspiring sculptural volumes using bamboo in innovative ways.

The Mepantigan Studio is defined by a central linear skylight bringing light into the middle of a large assembly space. Exposed bamboo structural elements create an expressive system of supports for its broad and generous roof. Exposed decking reveals the underside of the *alang alang* roof. Low retaining walls transform into stepped amphitheatre seating providing a broad

earthbound base contrasting with the soaring roof above. The interior of this light-filled space is used for daily school lunches, traditional Balinese martial and performing arts and community gatherings.

The Kul Kul Bridge is an elegant bamboo bridge. It is a pivotal piece of The Green School campus plan linking the west and east portions of the school and providing a metaphorical link between the school community and the local community. The bridge design provides thresholds at either end with enclosure and containment. This is contrasted with the middle of the bridge which reveals views up and down the Ayung River connecting you to the landscape beyond. The minimal but expressive structure sets a new design threshold for a bamboo bridge.

Heart of School is a dynamic sculptural volume that is located at the crossroads of all paths through the Green School campus. Three clusters of vertical bamboo columns create a multi-stemmed forest. Upper level platforms provide varying height spaces above and below. Soaring volumes are contrasted with more intimate but open spaces. The Heart of School explores the organic possibilities of bamboo as a vertical structural element defining interconnected light filled space.

The Gym at The Green School celebrates and exploits the structural bamboo arch to create a large column free space. The large structural arch provides an inexpensive big roof that can be built quickly.

I. Impact of the Project on the Site

The sustainability agenda for The Green School campus ensures that it is committed to a small ecological footprint. The campus plan respects the seven existing banjars that abut the site. The new pathways for the campus that have become a connective tissue supporting and adding to the existing pedestrian network serving both local villagers and the school community simultaneously.

The Green School's commitment to green alternative energy sources reduces any long term energy loads. The School's interest in and commitment to exploring the most innovative site infrastructure technologies is forwarding thinking and must be applauded.

The Green School buildings use local materials and they rely on the expertise of local craftsmen. The symbiotic relationship between the school community and its support of the social and cultural life of the adjacent neighbourhood and the Balinese craft tradition is an essential aspect of the project's positive impact.

The Green School master plan has understood the existing topography and its potential and inserted new buildings within the existing landscape. There have been minimal alterations to existing grade and the site could easily revert back to previous agricultural uses.

J. *Durability and Long-time Viability of the Project*

The Green School's approach to sustainability is tied to its long term durability. Using local building materials reduces transportation costs and ensures support for local farmers and labourers. Using local craftsmen to build the Green School buildings ensure that their expertise is valued and supported. Supporting local craftsmen supports the local *banjar* economy and ensures that the skills will be available for the long term maintenance of the Green School campus and for future projects.

K. *Ease and Appropriateness of Furnishings; Interior Design and Furnishing*

The bamboo furnishings at the Green School are an extension of their design philosophy. The school furniture celebrates the enormous possibilities of bamboo. Bamboo flooring, bamboo steps, bamboo shoe storage units, bamboo reception desks, bamboo lounge chairs, bamboo benches are all used on a daily basis by the Green School community.

Classroom chairs and desks are simple elegant solutions to the needs of students and teachers. All furniture is made entirely of bamboo; light weight and movable for different teaching requirements. School desks interlock in different spatial arrangements; they can also be separated for individual learning or adjoined in pairs and groups. Storage units act as both screening devices and storage, all inherently organic and playful. Additional freestanding units take the form of a pineapple, celebrating the creative and the practical.

The classroom is designed around 3 interchangeable and flexible spatial conditions; formal, informal and intimate. The classroom adopts a triangular plan, a large floating roof, open walls and minimal structural columns. The classroom is planned for maximum open space, facilitating flexible spatial arrangements to accommodate different teaching styles.

Within the triangular plan are located 3 interchangeable yet distinct spatial conditions:

- Formal classroom with desks facing teacher and black board.
- Informal meeting space with circular couches ideal for brain storming and creative thinking.
- Communal desk and work bench for art and group exercises.

VII. Users

A. *Description of those who use or Benefit from the Project*

The students enrolled at the Green School are the primary beneficiaries of its founder's efforts to create a living sustainability. Young people are educated about the challenges the earth will be facing in their lifetime. Wealth is generated where it is most needed – in the local community. Local farmers, local artisans, factory workers, administrative staff, kitchen staff, maintenance staff, construction workers sustaining the village way of life as the world becomes modernized. Balinese expertise in organic farming, renewable energy and

constructing innovative bamboo buildings is embedded in the Green School and can be maintained with an on-going symbiotic relationship with the local community.

B. *Response to Project by Clients, Users, Community*

There is a great deal of respect from the Southeast Asian architectural community for the Green School. There is a great deal of discussion about sustainability but the results tend to emphasize technological elements which have a limited impact on energy use while using a great deal of embodied energy. Architects in this equatorial region are very aware of the negative environmental impact that modern high rise air conditioned buildings are having on our planet.

There are few examples of a truly holistic approach to sustainability addressing all facets of footprint reduction. The Green School leads the way in speaking about the beauty of architecture, the role of sustainability and the stewardship of the environment all at the same time. This is considered an exemplary project responding specifically to its equatorial region and the particular issues related to its climatic zone.

The Green School was featured in the recent issue of FutureArc which is the leading magazine in Asia Pacific addressing architecture, design and sustainability. The editor in chief Dr. Nirmal Kishnani is aware of all built and unbuilt projects in the region. He is also associated with the World Green Building Council Asia Pacific Network and is committed to educating architects about their role in transforming our world to become more sustainable. In the recent article FutureArc article he stated, “The school is in its infancy; so we wish them well and hope the lessons learned here will translate well to other parts of Asia.” In the same article, he asks, “architecture without architects, it (The Green School) was designed by a sculptor – designer who worked with Hardy in his jewellery business. If this project needed no architect, yet is able to offer us reflections on Architecture and sustainability, what then are we teaching in schools of Architecture?”

“Well, this is my second visit to Green School. I was at Green School when it was really green, when it was just coming out of the ground. I’m back now and it’s about half done and I’m really excited to see it when it’s completed. I think it’s a fantastic concept. It’s been designed with a real vision in mind on how to educate young people about the world they’re growing up in and how to make it a more sustainable place. And so I’m really looking forward to visiting again once it’s up and running.” (Ann and Thomas L. Friedman, Pulitzer Prize winning New York Times columnist and author of the best seller The World is Flat)

“Fantastic...That was my first impression of Green School. The buildings are inspiring; its architecture design innovative and artistic. Bamboo, traditionally regarded as a cheap building material, once treated and preserved properly, has an awe-inspiring potential comparable to other commercially-used building materials. It is my great hope that Green School will contribute towards the development of affordable public housing in Indonesia by using beautiful and strong bamboo as alternative building materials. Once again, congratulations and keep the creative juices flowing.” (Mohammad Yusuf Asy’ari, Minister of Public Housing, Republic of Indonesia.)

C. *Popular Reaction to the Project*

The popular reaction to the Green School is overwhelmingly positive in its endorsement of the school's mission and visionary approach to education and sustainability interwoven.

"My job is to create wonder in people. However it's rare for me to get that same feeling. Thank you Green School, both architecturally and in mission, you inspire and astonish. You've accomplished a spectacular piece of visual magic with your Heart of School building. It's a breathtaking as the nature that surrounds it." David Copperfield, World Class Magician.

"Both visionary and practical, the Green School is a pioneering effort to turn young leaders away from the waste and pollution of the dominant culture, towards truly sustainable ways of living. The School's magnificent bamboo architecture is an outstanding example of the ecological, spiritual and aesthetic benefits of working with nature rather than against her." Helena Norberg-Hodge, Founder and Director of International Society of Ecology and Culture (ISEC) in London, environmental analyst, and Right Livelihood Award recipient.

"I applaud the aspirations of the Green School to create an educational experience that is built upon respect for Balinese culture as well as sustainability of nature. The world needs your inspiration and ingenuity." Peter Seligmann, Conservation International, Co-Founder and CEO and Chairman.

D. *What do Neighbours and those in the Immediate Vicinity think about the Project?*

The Green School has been well received by the neighbours in the immediate vicinity. The Green School is part of a complex multi-generational Balinese community of banjars. There are no security fences at the Green School. Their long term security is guaranteed by the school's long term relationship with their neighbours.

The Green School's commitment to the local community extends to a twenty percent intake of Balinese children who attend Green School through a scholarship program. Additionally the Green School has developed a program for educating local children about waste management and local schools are taking on projects to grow and maintain bamboo. The interaction and sensitivity towards the local and global community further enhances the unique international community focus. The Green School and PT Bambu also employ many local villagers to work for them.

"A sincere thank you for an absolutely inspiring day at our tour of the Green School. On behalf of the members that participated on our field trip, we all thank you. All of us were in awe of the progress with this exceptional endeavour and we wish you the best with the Green School. We hope in the future to be supportive of your scholarship program too." Rotary Club, Seminyak, Bali.

"Two thumbs up for Green School as I see this is very important contribution to build sustainable brand of Bali" Ayip, Bali.

“Wow! This place is amazing. Architecturally stunning and beautifully situated, the Green School is a model for all things possible in education. Global staff, balanced curriculum, community involvement, family-based housing and a vision for developing the next generation of great thinkers and leaders.” Bamboo League.

VII. Persons Involved

<i>Vision, concept and design</i>	John Hardy Cynthia Hardy
<i>Concept and Design Architects</i>	The late Aldo Landwehr Effan Adhiwira Yulianto Maliang Miya Buxton Philip Beck Cheong Yew Kuan
<i>Executive Director</i>	Kumar Bothra
<i>School Director</i>	Ronald Stones, OBE
<i>Design Manager Admin Engineers</i>	Marni Dalle Prof. Ir. Morisco Ph.D. Ashar Saputra, Ph.D Inggar S.Irawati, S.T., M.T
<i>Bamboo Consultant</i>	Jorg Stamm
<i>Meranggi Foundation</i>	Chris Major, director
<i>Project manager</i>	Ketut Indra Saputra
<i>Admission director</i>	Ben Macrory
<i>Operational manager</i>	Nina Thresia
<i>Operational and inventory manager</i>	Aswini Agarwal
<i>Inventory manager</i>	Puspita
<i>Finance manager</i>	Jeckson Sinaga
<i>Legal manager</i>	Putu Eka
<i>Human Resources manager</i>	Putu Suwarmika
<i>Design assistant</i>	Josie
<i>Purchasing Manager</i>	Anita
<i>Site supervisor</i>	I Ketut Moko
<i>Contractor</i>	I Ketut Sudarma
<i>Master craftsmen</i>	Sutanaya, I Gede I Made Kura I Wayan Murdita I Ketut Sumerta Budiarta, I Made Dama, I Wayan Agustina

VIII. Bibliography

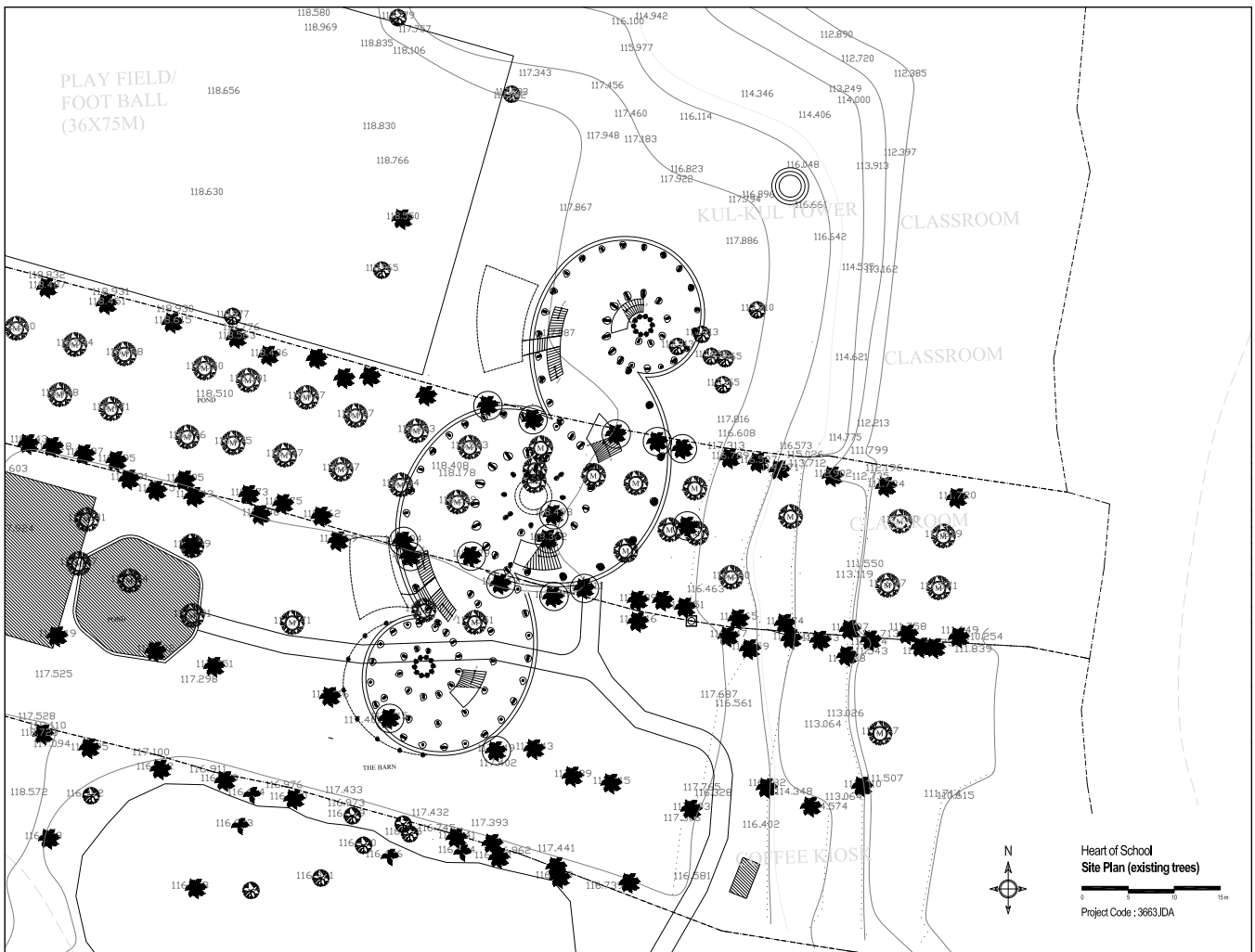
In progress.

Brigitte Shim

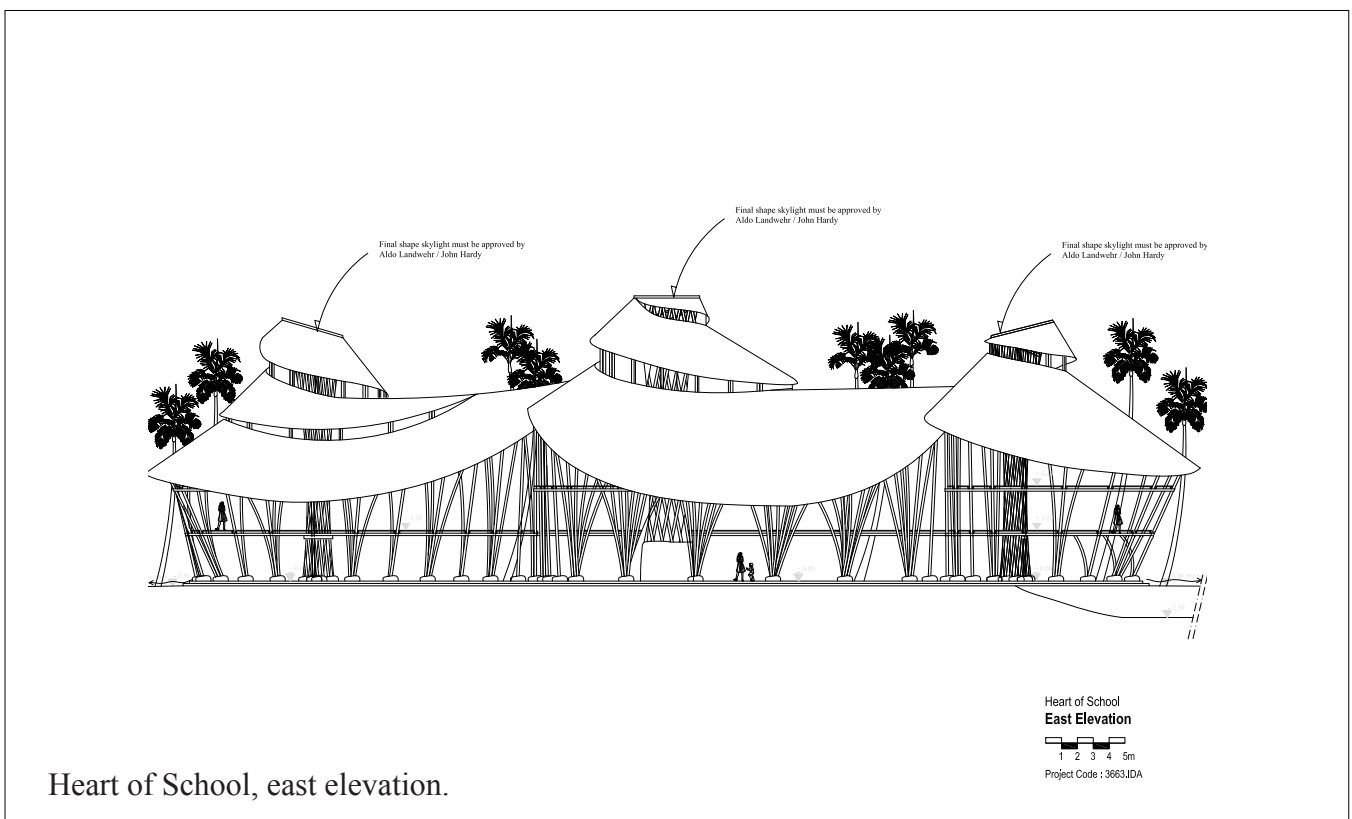
May 2010

* This report is the original, unedited version sent by the author on the 13th May 2010.





Heart of School, site plan.



Heart of School, east elevation.



Heart of School.

Interior view of the Heart of School bamboo roof.





Megantigan studio, exterior, multifunctional school/community/performance space.

Megantigan studio, exterior, multifunctional school/community/performance space .





Classroom.

Classroom.





Drama class in Heart of School.

Classroom n°3.





The Kul Kul bridge uniting the east and west lands over the Ayung River.



Entrance of the Kul Kul bridge.



Gymnasium and football playground.



Director's House.



Kitchen of the PT Bambu School.



Central part of the kitchen where is cooked all the food.

