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DESIGNING AND BUILDING A CHILDREN'S BAMBOO & HEMP PLAYGROUND.

Gie Steenput
Avans University of Applied Sciences, Tilburg, the Netherlands
gjpl.steenput@avans.nl

Abstract
A course named "Building with Bamboo" is part of the final year curriculum of the building engineer at Avans University Tilburg, AB&I, department of architecture. Within this course students can earn 2x3 E.C. over a period 2x10 days. From September 2015 up to January 2016 the subject of the course involved the designing and building of a children's playground made of bamboo and hemp. The playground is situated in Antwerp (Belgium) on the inner courtyard of an elementary school for children between 6 and 12 years of age. This particular school attracts a high number of children who do not speak Dutch as a native language. To help establish a better and faster communication with them, the children were invited to come up with ideas for their new playground. These ideas were transformed into 6 proposals by our building engineer students, and put on display at the elementary school. One design, chosen by the children and their parents, was picked out. Prior to execution our students prepared IKEA-like manuals to involve the children of the primary school in the construction of their bamboo playground as much as possible. Parts of the playground were prefabricated and a mock-up was made with the help of the children. Eventually the playground, a 3-dimentional labyrinth made out of bamboo and hemp measuring 5x5x5m, was erected in 4 days by 39 students. Protection methods against decay due to sun and moisture exposure were implemented. Special care has been given to the foundation of the bamboo poles and to lashing techniques used for connecting the bamboo pole structure. A maintenance manual has been given to the teachers of the elementary school. A follow up to study the decay of bamboo and hemp, being expose to a West-European climate, was planned.

Keywords:
Bamboo, hemp, communication, social integration, education, building techniques

1 INTRODUCTION

Prior to the realization of the bamboo and hemp playground in Antwerp last winter, over the years, several courses and workshops enabled us to get acquainted with the 'new' building materials bamboo and hemp.

All the courses where part of the minor 'Architecture', a program situated in the first half of the graduation year. The courses where structured as 'hands on' parts within the otherwise abstract curriculum of our building engineers. Students had to actually build something with their bare hands. The courses where stretched out over a period of ten weeks including weekly gatherings to exhibit, discuss and evaluate the ideas of students and tutors. Each course enabled students to gain 3 E.C., based on 1 day a week, of hard enjoyable work.

Workshops came less structured compared with the courses. They were all part of a bigger organization called ECOWEEK and provided students a period of 4 to 5 consecutive days to study and work with bamboo and rope.

As a result of the course 'Building with Bamboo' in the minor and the ECOWEEK workshop some students proceeded in exploring the possibilities of constructing and designing buildings incorporating bamboo as the principle material, in their graduation projects.

2 EDUCATING BUILDING ENGINEERS

2.1 Curriculum

The curriculum of the building engineer at the Avans University of Applied Sciences, Academy of Building and Infra Structure, has a 4 year program. It includes 2 periods of 6 months in which students are working within the daily practice of building or in architectural firms. The final year, the graduation year is divided into two periods of 6 months: the Minor and the graduation project.

The Academy of Building and Infra Structure has 3 departments: Urban Planning and Development, Civil Engineering, and Building Engineering. The latter has three subdivisions: Construction, Building and Architecture.

The MINOR Architecture

In total, students can earn 30 E.C. in the minor. The course 'Building with Bamboo' is one of 6 courses

running over a period of 10 weeks besides the main course consisting in writing a Thesis about a building related topic.

The course 'Building with Bamboo' is unique within the minor Architecture: students have to actually build something themselves.

We, the teaching staff, believe that different types of handing over knowledge to students helps them with a better understanding of what building in a society like ours is all about.

2.2 'Building with Bamboo' previous editions

In my papers 'Introducing Bamboo into the Education of the Building Engineer – So COOL – part 1 & 2 [Steenput, 2014] [Steenput, 2015] I gave an elaborate description of the content and education principles of the course 'Building with Bamboo' and it's evolution through the years.

This paper will only provide a brief description about the subjects studied and about the work of the students in the editions prior to the one of 2015-2016.

Edition 2012-2013

- *Course type:*

The course is workshop focused. Theoretical support is added in the form of generic theory sessions, expertise guest lectures on building with bamboo and on nodes.

- *Materials:*

Bamboo sticks 800 x 5mm and Bamboo poles 4000 x 25 mm

- *Assignment:*

Design and build a skeleton structure made out of 250 bamboo poles, each 4 m long and 2 cm thick, within a group of 4 to 5 students. Pay special attention, specifically to the materials securing the construction nodes, which should be, like the bamboo, preferably made of a sustainable material. The formation of work groups is left to the students.

- *Study program:*

The first seven weeks weekly assignments are to be completed by each group of four students. The result are to be presented the week following the publication date of the assignment. The work is evaluated on a weekly basis. Handing out the assignment of the coming week and evaluating the assignment of the past week takes 15 minutes. In week eight, students prepare to build their designs. Execution takes place in week nine resulting in the final construction. In week ten the projects are taken down and the materials are returned.

- *Study goals:*

Gather knowledge in working with skeleton constructions and construction nodes.
Learn how to design and make an innovative skeleton construction.
Be acquainted with bamboo, a non-conventional building material.
Be encouraged to work with sustainable building materials.
Practices experimental research and working methods.
Learn how to work within an interdisciplinary group.

- *Criteria used to judge the work, results, and process:*

Is the construction stable? Are the nodes stable?
Are the characteristics of the material fully exploited?
Is the material used in an effective way?
Is the construction complex?
Is the construction challenging in size? (Length, height, width)
Is the design of the construction elegant, well executed, finished?
Is the design of the construction original?
Is the design of the construction experimental?
Is a peer-assessment executed?

- *Teacher's expertise:*

The two tutors who gave this course are both architects by profession.
As it was the first time constructions with bamboo were introduced in the curriculum, students could not capitalize on previous experiences or specific expertise from the tutors. To compensate this lack of knowledge guest lectures were organized to gain expertise on bamboo characteristics and on making construction nodes with sustainable materials as well.
The tutors got well acquainted with the students, as a lot of contact with the students was involved throughout design projects, lectures, and workshops during a period of two years prior to the senior year.

- *General experience:*

The Bamboo poles of 4000 x 25 mm could not provide the strength necessary to stabilize the final models. Working with models on a scale 1/20 was clearly different compared to working with the models on a scale 1/2. Working on this scale produced some frustration within groups where big egos were found.

Edition 2013-2014

- *Course type:*

The course is still workshop focused. The theoretical support in the form of generic theory sessions, and expertise guest lectures were left out. The movie 'The Ron Resch Paper and Stick Film' (Resch and Armstrong 1992) has been shown, together with the results of last year's course.

- *Materials:*

Bamboo sticks 800 x 5 mm.
Hemp rope 2 mm thick.

- *Assignment:*

Design and build a flexible erectable dome made out maximum 500 bamboo sticks, derived from the skeleton structures of Ron Resch (Resch and Armstrong 1992), with a group of 4 to 5 students. Pay special attention, *specifically to the materials securing* the flexible construction nodes, which should be, like the bamboo, preferably made out of a sustainable material. The formation of the work groups is left to the students. Make a video of the proceedings and put it on YouTube.

- *Study program:*

No changes were made.

- *Study goals:*

No changes were made.

- *Criteria used to judge the work, results, and process:*

No changes were made.

- *Tutor's expertise:*

As it was the second time to introduce constructions with bamboo, and the first time to introduce flexible constructions in the curriculum, students on some topics could and on other topics couldn't capitalize on previous experiences or specific expertise from the teachers. Due to the main didactic approach of the course: teachers are coaching as much as possible. Revealing knowledge would jeopardize one of the goals of the course: to experiment and push ones limits. It was decided not to reveal gained knowledge to the group.

- *General experience:*

Working with hemp instead of rubber bands was great at first. But, an extreme amount of repetition eventually

caused frustration and boredom. Compared to the rubber bands used in previous courses, making the structures took a lot of time. Some of the students made comments about the failure of using bio-based materials solely on the basis of the time consuming factors.
However, students were very creative in making the necessary flexible nodes for the 'Ron Resch' dome.
The making of a video of the design process was challenging and seemed fun to do.
Edition 2014-2015

- *Course type:*

The course is still workshop focused. The movie of Aryan running after his bamboo soccer ball on the beach was shown. Students could grasp the idea: building a bamboo soccer ball was child's stuff.

- *Materials:*

Bamboo sticks 800 x 5 mm.
Hemp rope 2 mm thick.
Rubber bands.

- *Assignment:*

(1) Design and build a truncated icosahedron made out maximum 300 bamboo sticks. *Pay special attention, specifically to the materials securing the construction nodes*; those should be, like the bamboo, preferably made out of a sustainable material. Organize a race on the beach of Scheveningen, the Netherlands on 21 September 2014. The bamboo ball has to cover at least a distance of 100 m.
(2) Design and build and test a bridge spanning at least 1000 mm, made out of a 1000 bamboo sticks. The bridge has to hold a person of 80 kilo's while crossing it.
The formation of the groups is left to the students.
Make a film of the proceedings and put it on YouTube.

- *Study program:*

No changes were made.

- *Study goals:*

No changes were made.

- *Criteria used to judge the work, results, and process:*

No changes were made.

- *Tutor's expertise:*

As it was the third time constructions with bamboo were introduced, but only the first time a bamboo ball race and a bridge construction was introduced in the curriculum, students on some topics could and on others couldn't capitalize on previous experiences or specific expertise from the teachers. Due to the main didactic approach of the course: teachers are coaching as much as possible. Revealing knowledge would jeopardize one of the goals of the course: to experiment and push ones limits. It was decided not to reveal gained knowledge to the group.

- *General experience:*

Students were very creative in adding stuff to make their ball go faster.
They were also keen to study how bridges were made, especially while having a thousand rather small pieces to erect the bridge with.

2.3 'Building with Bamboo' edition 2015-2016

A dinner for 4

The play-device on the courtyard of the primary school 'Perspectief' Louizastraat, Antwerp was born out of a voluptuous dinner at the home of Barbara and Lieven. Els and Gie were guests, Lieven had cooked, and Barbara told us about 'her' school. As principal, over the years, she witnessed the arrival of many children with hardly any or no knowledge at all of the Dutch language. Communication was harsh. The integration of the children was taking forever.

The school seemed to be the proud owner of a worn down play equipment. Unfortunately, it got to small and did not meet the safety regulations anymore.

An idea began to grow. Why not design and build a new play element on the grounds of the school in order to improve the communication between the newly arrived kids?

Barbara would take care of the finances, Gie would outline some preparation of the play-device. Barbara got a grant of 10,000.-Euro, Gie came up with 2 design courses at the Academy Building and Infrastructure of the Avans University of Applied Sciences, Tilburg.

It was intended both communities, the pupils, their parents and teachers of 'Perspectief' and the graduation students of the profile architecture, would design and build the play-device together.

It was decided the project had to be executed with only 2 bio-based materials: bamboo and hemp rope.

A course called the 'Academy-project'

The first course was integrated into 'the Academy'-project, a third year course for the engineering students. Between February and June 2015. Students were asked to gather as much information as possible about bamboo and hemp: where can you get it, what are the costs, how to work with it, how to maintain it, which details should one pay attention to, how to make a stable and durable construction.

The course also requested for an instruction booklet to be made in order to help the elementary school children with the building of the play-device. Lots of images and little texts resembling a manual you get purchasing a wardrobe of Ikea. 30 students divided in groups of 6 were tutored by Tom and Gie. At the end of the course, two students, Tom (van den Broeck) and Kevin (Semil) presented the project to the teaching staff of the primary school. As a result, not only the majority of the staff was in favor to continue with the project, but also Annelies de Ruijter, the prevention adviser of the city of Antwerp, who became our biggest advocate.

Back to the course 'Building with Bamboo'

The second course was integrated into the minor 'architecture'. The final-year students studied the information gathered by their fellow students from the Academy-project and lifted the project to the next phase.

The first designs were adapted, or replaced all together, to meet the geographical measurements of the actual courtyard of the primary school and to meet the safety regulations applied to playgrounds for children in public schools of Flanders.

3 A CHILDREN'S PLAYGROUND

3.1 A new playground

The old playground had to go. The metal climbing frame including a metal glide got too small for the amount of children playing during daily breaks.

Old building plans of the school and its courtyard were provided to our students to enable them to study to find the best location for the new design.

September 15th 2015 the students paid their first visit to the elementary school. On the one hand the school yard was as expected, according to the plans received.

On the other, the children playing during the break came as a complete shock. Noisy, full of energy, they attacked the existing playground as if their lives depended on it.

These little human beings were going to be the users of the playground our students would design.

Many studies of the coming and going and the behavior of the children and their teachers were made by the students to understand the use of the courtyard.

3.2 Children's participation

It took several visits to the school, to explain what was going to happen. Our students have been addressing the children in an early stage: they went into their classrooms and asked them to join the design process. The children reacted with tons of drawings to express their wishes and dreams on the new playground.

4 DESIGNING THE PLAYGROUND

4.1 Children's drawings

After analyzing the drawings of the children our students synthesized the 'data'. The children preferred something to climb in (tree-houses, towers) something adventurous (a bridge, balance beams) something to play 'hide and seek' in, with private places where they could have a conversation with their friends in peace …

4.2 Design and security

A playground used by many children at a school in Antwerp has to comply with specific safety regulations.

According to Ben Walschaerts, prevention advisor, public schools Antwerp, several safety precautions had to be met in order to obtain approval for building a playground.

Climbing structures had to come with safety precautions to prevent children of breaking something while falling from the frames. Y-connections should be avoided or comply with a certain angle to avoid children getting stuck by the neck and hang themselves. Openings between two sticks had to be wide enough or to be avoided: preventing children to have their fingers stuck. Spaces between two rungs of a ladder could not be too wide or too small.

A booklet with all the safety regulations has been handed over to our students together with lots of wishes: "success!"

Not wanting to disappoint the children to much in case of a NO GO by the prevention officer, students decided on a pre-presentation to be attended by the prevention officer only. Some minor remarks were given. All 6 of the designs got the GO AHEAD sign: a presentation at the school for the children could be planned.

4.3 Six designs

The group of 39 students was divided into 6 smaller groups. Each of them got the same brief. Design a playground for the children at the school. Involve the children, their parents and the teachers as much as possible. Stay within the budget. Work only with two materials: bamboo and hemp. Make sure the design can be built in three days.

The competition

- *Group 1,*

Milou van der Linden, Jurre Mattheeuwse, Eva Massop, Montei di Matteo, Kars van den Meijdenberg, Bas Roijers, Amanda Verschuur and Djakko Rhymer designed the 'BAMBOO PLAYGROUND', a mix of Buckminster Fuller domes and a panna street football area.

- *Group 2,*

Coen Abels, Arantxa van Asenwoude, Jeroen Bastiaansen, Paul Bernards, Sebastiaan Boelens, Bregje Donkers and Pjotr van Kan came up with the 'BAMBOO BLOCK', a three level climbing frame including swing and seesaw.

- *Group 3,*

Han van den Eijnden, Susan Droesen, Joris Kemperman and Diederik Hermens, the only group without a scale model and a impressive computer animation instead, thought off a three dimensional labyrinth measuring 5x5x5m, named 'BAMBOO JUNGLE'.

- *Group 4,*

Charlot Verheijen, Kübra Mercan, Bart-Jan van Wijk, Christian Krielen, Bart van der Linden, Luuk Verhagen and Kimberly Semeleer decided on a combination of triangle constructions also called 'BAMBOO JUNGLE'.

- *Group 5,*

Justin Patty, Davy Mens, Yasin Onbas, Naomi van Lierop, Esther Liegeois, Thim Lans and Ritger Traag got their inspiration from celestials object. The project called 'MARS and VENUS' included several relative small pyramid shaped constructions, spread out over the school's courtyard.

- *Group 6,*

Guus Boel, Ruud de Brouwer, Casper Aussems, Nick van Kleef, Koen Kennes and Arbil Algan wondered about their own childhood and proposed 'FORT PANDA' a bamboo mase, not to complicated to built but good to suit the needs of the children.

The elections of the winning project

D-day was set on October 27th 2015. All the designs were exhibited in the multi-functional gym of the school.

It coincided with the schools 'open deur dag' (visit day). Children and parents were invited to take part in some festivities at the school and to take part in the election of the winning design of the new Bamboo and Hemp playground.

Despite the absence of a scale model, an overwhelming majority of the children and their parents decided on design number 3, the most elaborate, the biggest, and the most complicated to construct. The three dimensional bamboo labyrinth, the 'BAMBOO JUNGLE 1'!

A real challenge lay ahead.

5 PREPARING TO BUILD

5.1 The materials

Besides the two main materials Bamboo and hemp, woodchips were chosen to cover the surface underneath and directly beside the BAMBOO JUNGLE design.

Guadua Angustifolia, imported from Colombia, was purchased for the main structure, and Moso, (Phyllostachys Edulis) from China would be used for floor, ceiling and wall infill panels.

The thickness of the layer of woodchips was varying according to the height of the structure, at spots where kids could fall of: it ranged from 10 to 30cm. (4 to 12 inches).

5.2 Scale models

The design was chosen, materials were ordered: it was time to worry about the soundness of the structure of the BAMBOO JUNGLE. After seeking advice from a construction expert [Anne-Marie van Welie] alterations were made to the design.

Students made scale models to study de stability of the construction and tried to pinpoint exactly where and how many diagonal braces of bamboo poles were needed in order to get a stable bamboo structure.

5.3 Lashing techniques

As only bio based materials were allowed to construct the playground, special attention had to be given to the connections of different poles of the structure and to infill panels.

No iron or steel, no concrete, no nails, no threaded rods, bolts or nuts could be used.

A friend [Tania Cerrón] met at the WBC (World Bamboo Congress) in Damyang supplied us with useful information about making bamboo pole connections with rope.

The study [Hidalgo Lopez, 2010], of traditional lashing techniques used in Colombia proved to be very valuable.

The only thing left to do was to transform this 'academic' study in an exercise to help students, children, their parents and teachers to actually make these connections with only two materials: bamboo and hemp.

5.4 Insurance

A school is not a building firm. Therefor it wasn't easy to produce the right document covering all the angles of this enterprise.

We had to agree on several issues.

What to do in case of an accident? Who would insure injuries of children, teachers, and staff from the elementary school? Who would take care of injuries happening to tutors and students of AB&I?

What would be the agreement relating warranty of the playground?

In case of early collapse, who would be responsible?

In case of poor maintenance, who was to blame if the structure wouldn't hold up?

Eventually, the insurance firms of the two schools agreed to cover injuries to their own students, tutors, children and teachers while constructing the playground.

The work would be supervised and executed by the tutors and students of AB&I

Quality and maintenance of the construction was to be covered by the 'Perspectief'.

Ineke Toten.

5.5 Workshops

To practice with lashing techniques, teachers and parents and children were invited to the TTT-day (Technical Talented Tilburg) on October 20th 2015. Due to many reasons this workshop was ill attended.

On November 25th the workshop was repeated; this time on the premises of the school in Antwerp. Children and their teachers were taught to handle the smaller bamboo poles and the rope, and to assist with the making of infill panels.

5.6 Instruction manual

A mock-up, scale 1/1, was made to check the stability of the structure in real life and to find out if the studied work sequence would hold up. It didn't. Students had to rethink the building procedure in order to have the realization of the playground as smooth as possible.

The instruction manual that came with the design, had to be reworked.

5.7 Delivery of the materials

The student groups were very committed and revised the manual in time to start de building of the playground, December 7th, 8th, 9th 2015 - a date marked after consulting the staff and children of the school.

The disappointment was big when the delivery of the material got delayed. The promised delivery time could not be met due to the amount of orders placed in a very short period. The delivery would be delayed by at least three weeks. Cargo coming from Colombia always takes more time to get through customs compared to cargo coming from another country.

Because preliminary work was already executed in the courtyard (the old climbing frame and glide was removed, together with the rubber tiles underneath it) it was essential no more time should be wasted, to begin as soon as possible with the erection of the playground. New dates were set: January 4th, 5th and 6th 2016.

Everybody could start Christmas holidays with something to look forward too.

Everyone hoped that this second delivery schedule proved to be the right one.

6 THE BUILDING OF THE PLAYGROUND

6.1 Constructing the 3D bamboo labyrinth in 3 days

After moments of extreme stress, finally, the bamboo had been delivered on site in time: constructing could start as planned.

January 4th 2016 10 a.m. a bus full of eager students from Tilburg, arrived at the school in Antwerp.

6.2 Day 1

Fences

On the courtyard, the area where the construction had to be made was completely fenced in order to avoid accidents. The children of the primary school did their part in prefabricating infill panels: working with poles of 5m long, 0.15m wide, weighing 15kg each was left to our students.

The size of the courtyard, were the children used to play and make havoc three times a day, was reduced to a quarter. Some of the classes had to skip playtime on the courtyard altogether. Classes took turns to play on the reduced play court during the construction of their new bamboo-climbing-device.

It was imperative, for the saneness of the teacher staff, children could use the full courtyard as soon as possible, considering the promised amount of construction days.

Foundations

According to plan, rubber and concrete tiles were removed and stacked in a corner of the courtyard by a small group of Antwerp city workers.

The start of the construction proved to be a real set back. A team of students started to plot the positioning of the bamboo poles. All this had to be done according to plan. Measurements between poles had to be exact, poles had to stand at upright angles, and all the poles had to start at the same level.

Leveling out the ground was an underestimated task. The yellow sand supporting the rubber and concrete tiles, for several years, even decades, was turned into concrete. Several unexpected objects, not to be found on any building plan or document appeared to come out of nowhere. These unexpected guests, made out of pre-war concrete were very resilient and were not to be removed in a hurry. Time was running.

The positioning of the poles had to be revised. The whole structure had to be moved 50cm to the north. Additional concrete tiles were removed and stacked.

A wheelbarrow, a heavy duty concrete drill, a grinding wheel and other unforeseen equipment was flown in to get the job done.

Rubber tiles were used as a foundation. Placing them at the foot of each pole they could be stacked two or three tiles high to get the feet of the poles all at the same level.

Rubber tiles were also convenient to avoid injuries caused by falling down. A concrete foundation had to be placed much deeper and covered with a thick layer of woodchips to break the fall of a misfortunate child. The extra thick layer at the foot of the bamboo column would increase the risk of moisture decay of the bamboo shaft.

Preparing the bamboo poles and hemp ropes

While some students were tackling the 'unforeseen' aspects of the project, others were busy arranging the bamboo poles according to size and unpacking the hemp ropes.

Cutting the purchased bamboo poles to dimensions as planned, was intended to be done by hand. This idea was abandoned quickly: electrical equipment was used to preserve the time schedule.

After cutting, the edges have been trimmed, leaving no splinter to harm an innocent child's hand.

Some parts of the bamboo poles had to be dried with a heat blower to prepare them to be covered by resin. The resin itself, was covered with sand which gave the bamboo poles enough friction at places of interconnection avoiding any sliding or movement between two connected bamboo poles.

Further, hemp rope was rolled out and cut into pieces of several lengths making it fit for the connection of two poles or the weaving and binding of the infill panels.

Raising the first 5 poles

When the bus arrived to pick up the students at 17:30, the first row of five large bamboo poles forming one of five structural elements were made - one of five: it took one day.

The element was raised and fixed to the wooden frame of the existing steel sheet roof, covering the courtyard partially.

Students were proud and worried at the same time. Proud of what was accomplished, worried about the time schedule.

Only one of the five construction elements was standing: four more to go! Will the work be finished as planned?

6.3 Day 2

The bus arrived early on day 2. As early as 9.15, everybody was checked in and at work.

Some serious re-planning must have occurred during the drive back to Tilburg on the bus the evening before. Everybody knew what was expected and students were busy doing what needed to be done. Spirits were high.

Some were busy weaving the infill wall panels, which measured 1,2x1,2m and were made entirely out of hemp. Others were making bamboo partitions with identical measurements, from Moso bamboo sticks (2cm thick) and hemp rope.

The largest team of students worked on the bamboo construction elements.

Students had been making arrangements with the bus driver to be picked up at 18:30, an hour later than the day before.

At the end of the day, after a shift of 9 hours of harsh work, 3 constructive elements were added and standing. The fifth one was lying on the ground, waiting to be mounted the next day.

The majority of the infill panels was prefabricated.

Planning concerns were disappearing. At that point, to finish the job, students would return one more day.

6.4 Day 3

Working like hell

9:24, at the crack of dawn, the last piece of the construction elements was fixed to the four standing. In addition four bamboo floor panels were mounted. It was time to unleash the entire structure as it was still fixed to the wooden structure of the courtyard's roof. A breathtaking moment to come. Is the structure going to be stable? Or would it start to slant or slope or tilt? Or collapse altogether? It was the students' first building experience in real life.

After releasing the fixtures the structure didn't move an inch. Firmly standing by itself without the need of digging deep foundations to fix the 24 poles of the construction to the earth. Preparations and studies had been paying off. A moment of victory!

However lots of work still had to be done. The structure had to become a children's paradise. 23 bamboo wall panels, 8 bamboo floors, 6,5 bamboo ceilings, 4 hemp wall partitions, 1 hemp ceiling, 1 hemp bridge spanning 2.4m, 1 hemp bridge spanning 1.2m and a hemp sloping bridge spanning 1.2m rising or descending 1.2m, 2 bamboo ladders and 1 hemp climbing net of 1.2x3.6m still had to be installed.

At 10:30 the first wall panel was fixed onto the structure.

At 10:36 it started to rain.

A non-bio canvas was gathered to cover the structure temporarily to protect our hard working students from the rain. The prefabrication of the floor, wall and ceiling panels continued.

At 10:55 am, ladders were assembled.

At 10:56 the school principle left the scene trying to find some shelter against the elements.

Time for a treat

00:21 pm January 6th, cakes to commemorate the visit of the three kings from the east to the new born Jesus, were brought in. To lift the discouraged spirits we ate cake and crowned ourselves kings.

00:36 pm, it stopped raining.

Resuming work

01:10 pm, the bamboo bearing structure is finished.

01:12 pm, everybody joined in to connect floor, wall and ceiling panels to the main bamboo structure.

01:15 pm, holes were drilled to enable air coming in giving moisture a chance to evaporate. Half a foot above the woodchip layer holes did let in the air at the bottom of the pole. Poles were drilled along their longitudinal axis, treating them against vermin and bacteria. Because the chambers of the poles were already pierced air within could rise by the heating of the sun during daytime, taking away the moisture risking to settle at the bottom of the poles. Moisture should be enable to evaporate within the pole and leave the pole through its top section.

Connections had been inspected, the work is photographed and documented. Finished infill panels were fitted in and adapted for installation at designated spot.

01:34 pm, the six bag filled with woodchips, each weighing 200kg were moved and unpacked.

02:15 pm, the installation of the biggest hemp bridge had begun.

02:44 pm, finishing the edges of the area of the woodchip layer was coming to its end.

03:30 pm, while continuing the installation of walls and ceiling panels, woodchips were spread over the area underneath the children's bamboo dream. Around the highest climbing spot, enabling children to fall off, the surface of the woodchip layer had to be extended and made thicker. As it was impossible to break to the hardened soil once more, another solution had to be found.

04:17 pm, with the mesmerizing rhythm of Michael Jackson's BEAT IT (what's in a name) coming loud from the speakers, half of the group found itself at the bamboo installation, racing against time.

05:08 pm, lights were lit, the day approached its end, and darkness did set in. The work continued while some students started to clean the school yard.

07:30 pm, to dark, to tired, the project isn't ready to be handed over to the children. Students it would take another effort of 2 to 3 hours with a group of 6 students to finish the job. They were to keep me informed when this would happen and which students were to come back for the fourth day of work.

During the one hour drive back to Tilburg students had a meeting. The result arrived in the message all of them would come back on January 11th 2016. The project itself became a team building experience.

6.5 3+1 days

What was estimated to be a job of 2 maximum 3 hours for a group of 6 students ended up by taking most of the day for the group of 27 who actually was at the site.

The difficulties met at the beginning of the job regarding the foundation of the 24 poles proved to be too big to do the job in the estimated three days. Nevertheless a feeling of pride at the end of day 4 was rightfully theirs, when returning home at 18:54.

The area closest to the highest point to climb and fall of had still to be finished. Raising the thickness of the woodchip layer meant purchasing and installing sloping rubber tiles especially made for this purpose. This part of the job was to be done by the city workers. Eddy Palmer, the principle of the school would see to that.

The school could set an inauguration date at last. Everybody was really excited, especially the children. On January 22nd 2016 the multi-level bamboo-climb-hide and seek-3 dimensional labyrinth would finally been given to the children.

The road to a joyful moment was laying right ahead.

6.6 Security check, one more time

The security officer checked the play installation one more time. Still some minor improvements were to be made to allow the children's access to their bamboo playground. Small gaps had to be made smaller, a drop of 1.2m had to be reduced for safety reason.

Although the play installation was build according to the documents presented, our security officer had not noticed these minor omissions before. Presentations and the real deal is not the same thing, even for a safety inspector.

Unfortunately it was bad timing. For communicating these findings at this point, so late in the process, proved to be uncanny to the students. Students had done their bit and had gone off to their regular University life.

So January 20th 2016 the two tutors Michiel and Gie spend one day doing the last bits and pieces. And there it was: the final GREEN light.

6.7 Impatience, inauguration and gratitude

The most raised question by the children from November 2015 up to January 22nd undoubtedly was: "When will it be ready?"

The newly appointed lector at the lectureship Bio Based Building Willem Böttger came along to inaugurate the new Bamboo and Hemp playground.

The children expressed their gratitude with lots of drawings. It was a hart warming moment.

7 THE PLAYGROUND IN USE

7.1 150 children versus bamboo and hemp

For 20 minutes, three times a day, every day of the week a real attack was launched. Something had to give.

7.2 First signs of decay

The initial use of the playground during the first weeks resulted in discovering the flaws in the design.

Main structure

The overall structure, made out of bamboo poles 10 to 12cm wide and hemp rope 10 and 12mm wide, was rock steady. No problem there.

Infill panels – bamboo walls

The fragile parts of the playground suffered the most.

Bamboo wall infill panels started to disintegrate. The thin vertical bamboo sticks got loose from the panels. The sticks had been attached to a frame, unable to withstand the pressure of the playing children: it appeared to be too weak

Ladders

The last parts constructed were the first and most used and tested by the children. These parts had been put together in a hasty manner in order to meet the construction deadline. Resulting in the redoing of the connections of the rungs of the ladders.

7.3 One final shot to get it right

Repairing the damage

In March 2016, a group of 8 students, still lacking 2 E.C. each, paid one last visit to the school to do the repairs. The infill panels and ladders were taken care of, a temporary solution, a part in wood, had been replaced by a hemp net.

Optimizing the maintenance manual

Leaving the primary school one last time went with the handing over the booklets and manuals to the staff of the school. The aim was to enable them to make the future repairs by themselves as was agreed upon in the contract.

Students of Avans University of Applied Science were expected to do checkups every 6 months and to monitor the behavior of the playground.

7.4 Reoccurring decay

Infill panels continued to fall apart. It became clear that the bamboo and hemp (Hempex®) playground could only be used for two consecutive days followed by three closing-days, needed to make necessary repairs.

The decay of the infill panels was too much to keep up with for staff of a primary school whose core business of is not maintaining infill panels which became almost a daily task. Instead they had to take care of the children and their development: a hard day's work as such.

Hence, the school decided to contract a carpenter to make necessary changes in order to give the children their daily playground back and ensure the teachers' daily rest.

8 THE PLAYGROUND AFTER ONE YEAR

8.1 The playground today

Counting from the beginning of the new schoolyear in September the playground stood firm and not a day of repairs was necessary up to now.

Classes are taking turns to in using the playground. The number of small accidents is relatively low, serious ones did not occur up to this moment. One can call this a success, especially compared to other playgrounds of the same size.

8.2 The main structure - alterations

Almost none or problems too small to report were identified considering the main structure of bamboo and hemp.

It must be said students admitted, long after the construction had taken place, they had been using Hempex® instead of hemp to make the connections of the main structure. The argument is that Hempex® is more resistant to the local weather conditions. Hempex® is very similar to hemp, has the same appearance. However it is manufactured synthetically.

Notwithstanding that the 'feet' of the bamboo poles are looking dark brown, tapping on them showed they were still firm.

8.3 The infill parts – alterations

Ground floor:

Heavy tree trunks have been added to mark the playground, replacing the sloping rubber tiles.

Moreover, the woodchip layer is been replaced by another new layer of bigger wooden chips to avoid dragging in muddy particles into the classroom, making the cleaning ladies very happy.

Today, steel screw connections are added to both of the ladders.

1 bamboo wall panel is been removed.

First floor:

2 bamboo floor panels are been replaced by wooden floor panels. 1 wooden floor panel is added. 2 bamboo wall panels are been replaced by wooden wall panels. 1 wooden panel is added. 1 hemp wall panel appears to have a gap of 10x20cm.

Second floor:

1 wooden wall panel is added, 2 bamboo wall panels are been replaced by wooden wall panels.

Summary:

One out of 22 original bamboo wall panels is removed, 4 are replaced by wooden wall panels. In addition to this, wooden wall panels are been added to increase the safety of the children – 17 bamboo panels survived the first year of use.

The original 4 hemp wall panels, are still in place, one was showing a gap of 10x20cm.

From the original 7 hemp nets, not one was removed. All of them are still intact.

2 out of 12 original bamboo floor panels were replaced by wooden floor panels, 1 was added to increase the safety of the children.

9 LESSONS LEARNED

9.1 Maintaining a bamboo hemp structure

Compared to a steel playground, the bamboo, Hempex® and hemp playground needs a lot of love and care to maintain those parts that eventually let go. Knots are to be inspected. Bamboo wall panels need to be restored.

The energy implied in restoration of the bamboo wall panels - due to a poor design - was underestimated.

Concerns about safety regulations caused the closing of some access points of the bamboo Hempex® hemp playground by wooden panels. Safety regulations or at least its interpretations tend to harshen every year.

9.2 The cost of a steel versus a bamboo hemp playground

Surfing on the web, you will find steel playgrounds with none or barely any maintenance required.

¼ of the volume of the bamboo playground has an average price tag of 15.000,-€. The cost of materials of the bamboo hemp playground are kept within the budget of 10.000,-€. When the hours it took to install the playground are taken into account, the bamboo hemp playground has an estimated market value of 25.000,-€. Conclusion is that it is still cheaper than a steel structure of equal size.

9.3 The learning process

When, nowadays, on rare occasions I meet students who participated in the bamboo hemp playground construction, they are happy to state that it was the best course of their 4-year curriculum. Through actually constructing a structure themselves, students learned and understood what construction is all about.

I do not know if the building process has helped the children to integrate more quickly in the elementary school. Today, sitting on a bench, looking how the

children are playing on the bamboo Hempex® hemp playground, some of them came sit next to me, asking: “could we have a bamboo glide?”

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