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YIN YANG PROJECT. BUILDING ON A LARGE SCALE AND THEIR EDUCATIONAL POTENTIAL.

FERMÍN GONZÁLEZ BLANCO [1], MANUEL F. HERRADOR [2]

[1] Professor of Construction Systems. IE University
Calle Santiago+Nº4, A Coruña+15001, Spain
correo@ferminblanco.com - www.ferminblanco.com

[2]ETSI Caminos, C. y P. – Universidade da Coruña
Campus de Elviña, s/n, 15192, A Coruña, Spain
mherrador@udc.es – http://www.gcons.udc.es/

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Abstract.

The project is a reflection on the educational potential of the act of construction, specifically, large-scale construction, which is considered to be one capable of "competing" with the scale of the participants.

The conclusions and data obtained come from a series of experiences linked to the collective "Sistema Lupo". This group has developed many educational activities, related to the structures and other topics, from an empirical and experimental point of view.

The main material used is building blocks, on different scales and materials and delimited by a modular construction system [1] that allows infinite rigging.

The size of the blocks used emphasizes the need for a proper design and allows the participant to be aware of the functional and aesthetic aspects of a good structural design [2]. The scale of the constructions, larger than that of the participants themselves, requires a team effort and success or even failure is shared by all. The didactics also values the uniqueness of the individual in the group. It is a difficult interaction that includes participation, discussion, creativity and resilience as a result of the failure of demolition and its reconstruction.

The experiences have been developed in very different environments ranging from university to children's classrooms. The current proposal refers to a specific project developed over the last five years in the university context. The main material used is wood and, in addition to the above-mentioned topics, industrialization and the design, manufacturing and assembly processes are also included [3].

The educational program includes the study of structures and the evolution of the techniques of construction and assembly throughout history. The workshops start with a theoretical approach, go on a guided activity and end with a creativity phase.

1 THE PROJECT

The present document shows in detail the project of a series of participative workshops related to material (timber), teamwork, process, module and, also, creativity. It is an open project that professor Blanco uses every course since 2012 at IE University.

The originally seminary formed part of the Segovia Hay Festival in 2012.it was a result of a collaboration agreement between IE University and the American Hardwood Export Council. Its main objective is to show the properties of wood as a material that joins tradition and avant-garde in the field of architecture, design or engineering. This aim is achieved through education, in this case at university level, with students of architecture in their last year.

For this workshop, we propose two simultaneous activities in two singular points of the city of Segovia; the Aqueduct and the Casa de los Picos Palace, the headquarter of he Design School of the city and one of the official venues of the Festival.

Both workshops used Lupo System´s own didactic technique and geometric forms. Lupo is a didactic tool created by the architect Fermin G. Blanco, who is at the same time professor of Construction Systems at IE University and the coordinator of the Timber Seminar.

Rather than creating a sculptural piece, in this case we propose a participative project where the process is as important as the result. In fact, it is conceived as an ephemeral architectural system, with an infinite number of uses and possibilities.

Dismantling the structure is also part of the workshop, after this it can be reused in any location and with any other form and objectives.

The material proposed for all this activity, which can be seen as an art performance, will be tulipwood, whose properties of lightness, resistance and finish will be the protagonist of each step of the project.

Figure 1: Yin yang project

2 LUPO SYSTEM

Lupo is a modular system patented by architect Fermin G. Blanco.

It is a set of basic pieces with proportional forms and dimensions allowing a diversity of combinations.

Its original objective is a didactic game tool. THE PROCESS is fundamental for the activity and THE ACTION is the medium. Equilibrium and form are the elements that

enhance the ability of vision in 2D and 3D and intellectually challenging the user to stimulate coordination, memory, sociability and creativity.

Figure 2: Lupo system

2.1 Bigger scale

Timber Lupo is a project that multiplied by four the size of the Eco Lupo original model. It was created reproducing the original geometry of the pieces while adopting the joints and the manufacturing process to this change of scale.

Figure 3: Change of scale of the original Eco Lupo pieces

2.2 Packaging

The manufactured material should be adapted to the transport conditions, not only for this workshop but also for future uses. In this way, pieces made during the manufacturing process will be packaged in cases made up by themselves.

Each case (400x400x420 mm) is adapted to European pallet, so each pallet contains 12 cases as it is shown in the figure. Due to their drill holes, the top and bottom lids of plywood boards can be used as a foundation for Lupo constructions.

The weight and dimensions of each case allow for being manipulated by one or two users.

The packaging reproduces in a large scale the distribution system of Eco Lupo (19 pieces) as shown in the figures.

Figure 4: Case drawing and packing strategies

3 MANUFACTURING PROCESS

1. Manufacturing of boards from planks which are joined together laterally using finger joints and are glued together in three pieces to reach the height of 100 mm. (size of the finished element).The joints have to be put in alternative positions in order not to make continuous joints in the vertical section of the piece.
2. Compression and calibration of boards with dimensions 550 x 550 x 100 mm (depth).
3. Cutting of pieces following Lupo System´s patent supplied by authorized Lupo System personal. Cutting with CNC machine making use of the leftovers to obtain pieces and lightened boards.
4. Transversal drilling of pieces. Manufacturing of joint pieces between lightened boards.
5. Finishing. Sand and finishing with transparent and open pore laser.
6. Packaging the pieces for shipment in cases of size 400x400x420 mm, using European pallets (12 cases for pallet). The cases will contain upper lid and bottom lid for their manipulation and distribution.

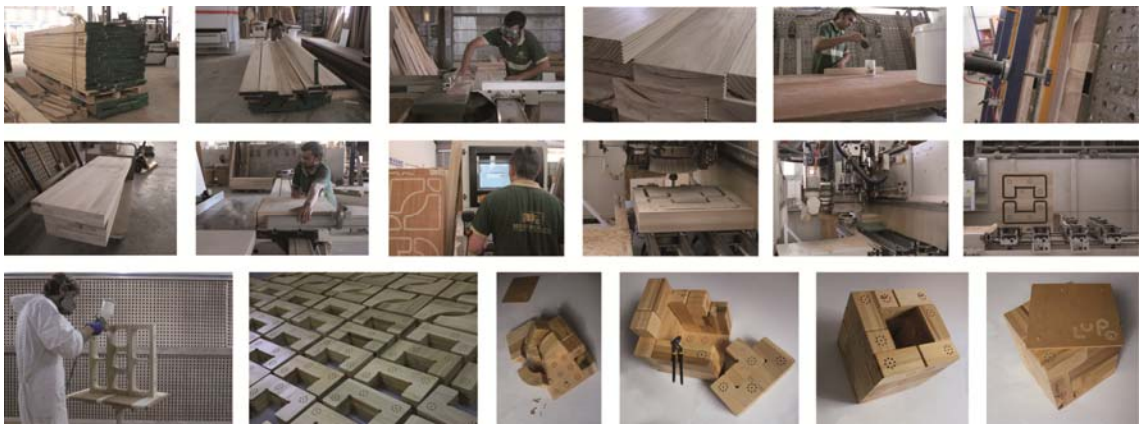

Figure 5: Manufacturing process.

4 INIA-CIFOR STRUCTURAL LABORATORY

The permanent challenge during the building process is the exclusive use of wood. This has been possible thanks to the collaboration with the structures laboratory of INIA-CIFOR.

Both the material and the finger joints made during the manufacturing process were tested in the laboratory. We tested separately the resistance of the frame and of the whole element and obtained surprising results (in spite of their fragile appearance).

After this, the experiment concentrated on the joints, trying to resolve through the same joint element the different situations that could appear in the structure. We wanted to find a piece that could work in tension or compression (depending on the case). After a study of traditional Japanese solutions like Komi-San or Hana-San, the final solution is constituted by the use of dowels and sleeves, all made in American ash.

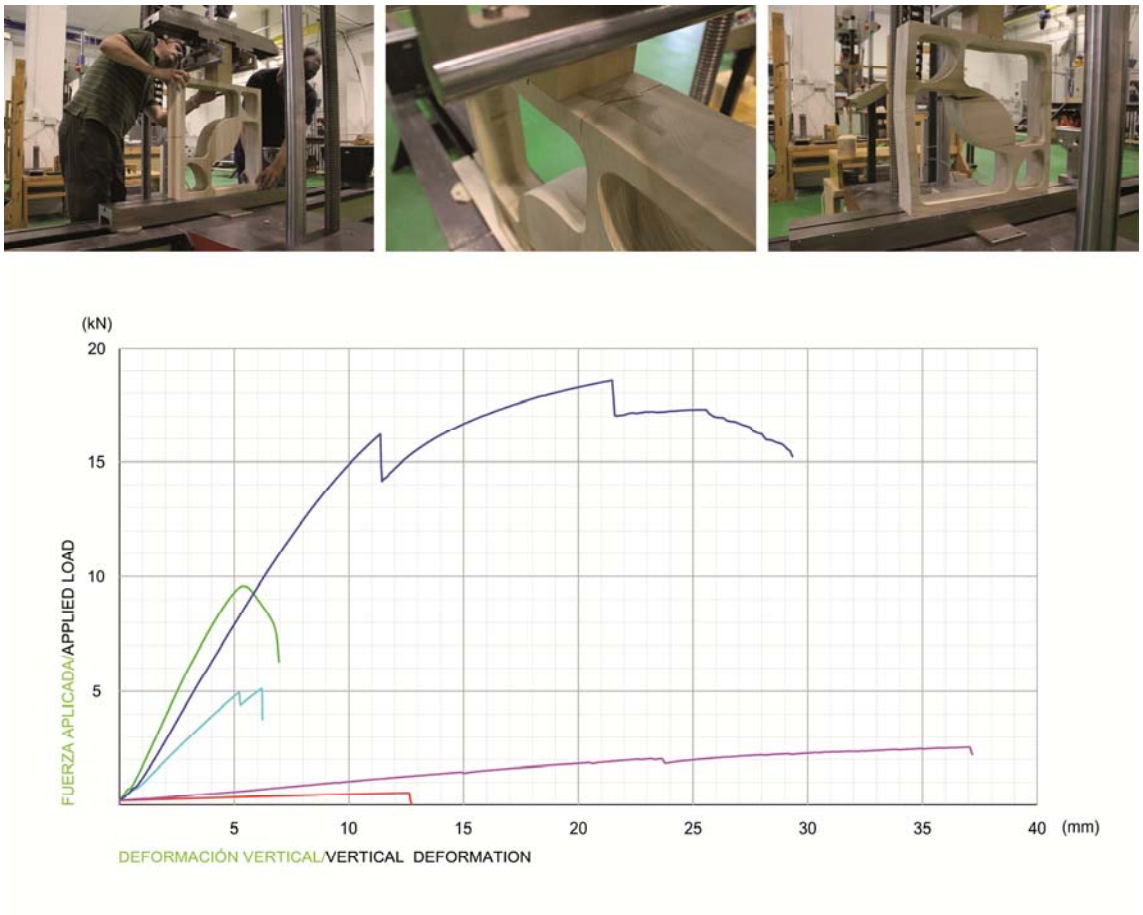

Figure 6: Test of the pieces in the INIA-CIFOR structural laboratory and results of the tests

Table 1: Frame test, template test and templates and system joints test.

Test	Section (mm)	Force (KN)	Deformation (mm)
Frame test			
Bending test Grain and load applied in the same orientation	100x27,5x550	0,53	12,58
Compression test. (buckling) Grain orientation perpendicular to load applied	100x27,5x550	9,59	5,43
Template test			
Compression test Grain and load applied in the same orientation	100x550x550	4,94	5,21
Compression test Grain orientation perpendicular to load applied	100x550x550	16,19	11,36
Templates and joints of the system			
Cantilever test Grain orientation perpendicular to load applied	100x550x550	2,55	36,96

5 YIN YANG TULIPWOOD

The results are two complementary projects based on the same production process.

The Roman aqueduct replica built with the “positive elements” shows the capacity of wood as material ready for its shaping in the field of design and architecture. That is, a natural material easy to manipulate and shape, quite lightened (due to its density) and aesthetic.

The Sponge is a complementary project, built from the “negative elements” made during the manufacturing process of the pieces for the aqueduct. In this case, the pore structure shows the structural possibilities of wood. The structural challenge is attained the strategic organization of the 92 squared pieces riddled with holes (in a 60% of their surface).

Figure 7: Yin yang project

6 THE AQUEDUCT

The Roman aqueduct of Segovia is one of the most important Roman constructions in The Iberian Peninsula and also the universal symbol of the city.

The aqueduct consists of a mount of 20400 big blocks of granite (7500 m3 of stone) shaped and organised according to their position in the structure. The shapes of these pieces not only depend on their structural logic, they are also made according to the construction process used. Each part of the aqueduct is different but at the same time constitutes a systematic whole where everything is organised from the process through cutting the blocks to their final placement in the structure.

6.1 Construction of the replica

Following the same logic as in the original one, the process of manufacturing and transport is systematized to build a replica of the aqueduct. The result will be the replica of the Roman aqueduct of Segovia, in a 1/10 scale, making a puzzle of 336 pieces.

In each of the six pillars, that make part of the replica, the position of the pieces is different, although the general composition is the same. As in the case of the original one, none of the pillars repeat composition; however, they are all the same shape and size thanks to the system. The replica reaches a height of 2.80 meters and a total weight of 453 kg.

Figure 8: Construction of the aqueduct of Segovia replica

7 SPONGE

In parallel with the construction using Lupos, the construction with the “negatives” allows us to test Tulipwood as a structural material. The Sponge is a completely lightened structure, fruit of the manufacturing process of Lupo pieces. Each board has been projected in order to obtain four squared elements (550 mm size). Each element has been tested in the laboratory together with the joints.

To organise the process of building the structure, we projected a system of different levels of assembly to be built by the students. The Sponge has a labyrinth structure (3.70 m size) which the visitors of the exhibition can walk through. Its elements are organized in the shape of a cube; the disposition of each element tries to meet different structural challenges using cantilevers and beams supported by a mash of pieces.

Since this project is inspired by the idea of the process and the complementarity of solutions, we have decided to link the two projects, the Aqueduct and the Sponge, during the building process. In the plans for the building process, we can see different abstract drawings that reproduce the original mason’s marks on the stone blocks of the Aqueduct. These marks,

which identify the work of each particular stonemason, can be seen even today in several parts of the monument

7.1 Concrete Lupo

The need to ballast the Sponge structure was a new challenge that was solved through manufacturing the concrete pieces, in this case using timber as formwork.

Figure 9: Concrete Lupo

7.2 Joints

Most of the tradition of the use of wood throughout the world has been based on its own properties of resistance, which allowed wood to be very useful in structures. The discovery of new construction materials throughout the history has improved the solutions and the range of possibilities, but even in our days, wood is considered in the field of architecture and design as a contemporary material.

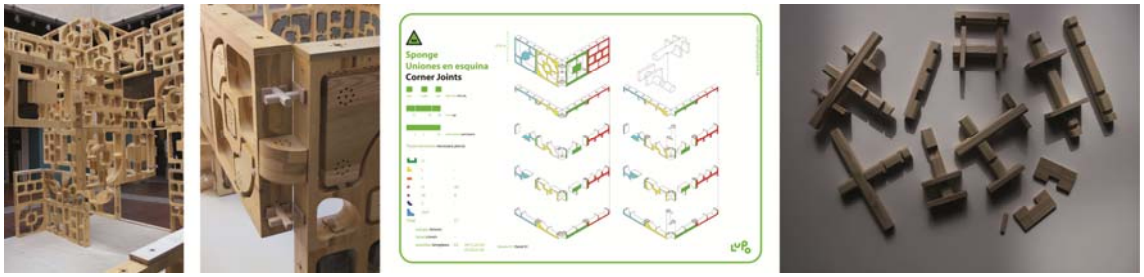

Figure 10: Sponge joints

7.3 The didactic balance.

This didactic project was conceived to explore the material and its possibilities. It was a challenge to try to build this structure without help of glue or metallic screws in joints, that is, in a traditional way by the exclusive use of wood. This method has allowed us to understand wood in all its magnitude, getting to explore its natural composition and its building qualities that allowed us to use it effectively in construction.

This project has maintained a balance between theory and practice, implicating the students in the different steps of its development.

The manufacturing process of the wooden pieces has been at the same time served as a test bank for finding necessary solutions. As a part of all the didactic process, in the carpenter's workshop, we not only manufactured the pieces, but also carried out tests for possible solutions, which would also be tested using models and experiments in professional structures laboratories.

This project represents an overview of all components of construction, from innovation, through manufacturing, assembly to structural security, all constituting a logical mixture of professionalism and learning.

Figure 21: IE students during the construction process

8 HAY FESTIVAL OPENING DAY. THE HUMAN CHAIN

More than three hundred volunteers took part in the popular workshop by carrying the components of the Aqueduct replica to the Casa de los Picos palace where the pieces were stored in the negatives of the Sponge, that public engagement is important in this type of projects just to emphasize the social commitment of education.

Figure 12: Aqueduct replica, human chain and Sponge

9 FOLLOW-UP PROGRESS

Throughout the years following the 2012 workshop of the Hay Festival in Segovia, the collaboration between IE University and Segovia City Council has continued to generate new interventions. Every course new students come and participate in this workshop, during the theoretical part they create small groups and propose a project to build using the system, we

discuss every project and finally we merge all ideas into one. Second part of the seminar is the practical workshop where students have to build the idea in a collaborative way.

Figure 13: The Labyrinth. 2014. Real Ceiling. 2015. Swing and Yang. 2016. Wooden Pyramid. 2017.

Opening the Lupo box means starting a teaching and educational process. As in every learning process, challenge is a motivating element that encourages teamwork towards a shared objective. The process offers infinite possibilities and repetitions but it always finishes at the same point, with all the material picked up, without any noise, promoting the reflection... Each time the box is dismounted, a new process starts…

Figure 14: Timber Lupo box.

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