Lightweigh & Sustainable protection ///

Project data

Thesys students: Elia Tomat, Marco Zerbi

Thesys title: Lightweight protection. Design of a temporary, adaptable and reversible shelter for Nora's archaeological site

University: Politecnico di Milano

Faculty: Architecture and Society

Master degree: Sustainable architecture

Supervisors: Prof. A. Campioli, Prof. E. Rosina, Prof. A. Zanelli

Academic year: 2010/2011

Elia Tomat

Marco Zerbi

Teamwork

Politecnico di Milano, BEST - Technology department
Politecnico di Milano, BEST - Conservation and restoration department
Archaeological superintendence of Cagliari and Oristano
Politecnico di Milano, Physics depart

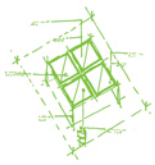
Teamwork

Thesis characteristics

Thesis subject: Design of a temporary, sustainable, adaptable and reversible shelter

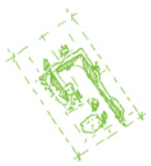
Research aims: Experimentation of technologically adavanced and low-impact protective solutions

Research's sustainable criteria: dry construction techniques, innovative use of standard componentry, disassemblability, recycle, reuse, energetic self-sufficiency, low embodied energy and CO^2 emissions

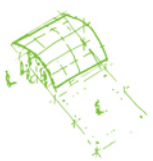


Keywords

1. Physical conservation of the archaeological remains



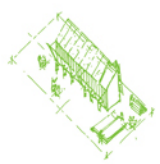
2. Full reversibility and low archaeological impact



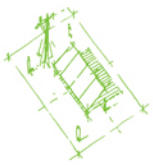
3. Modularity and expansibility

4. Lightness and transportability

5. Performance improvability



6. Energy self-sufficiency

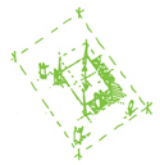


7. Compatibility and durability of materials

8. Disassembly and recyclability of components

9. Protection from environmental factors and internal comfort

10. Quick and easy installation and maintenance



General report

"One of the half-cities is permanent, the other is temporary,
and when the period of its sojourn is over,
they uproot it, dismantle it, and take it off,
transplanting it to the vacant lots of another half-city."

Italo Calvino, The invisible cities, Sofronia

With the aim of guaranteeing a low level of archaeological impact and a high reversibility, we were inspired by the idea of lightness and temporariness. We thus proposed a protective system that differed from current practices which are characterized by:
• the strong roots to the archaeological site and therefore their impossible reversibility;
• the strong commitment of the architect to impose his vision at the expense of the archaeological remains.

We therefore thought to a lightweight, portable and adaptable system, that had to ensure both optimum preservation of archaeological remains and their visitability in a sustainable way.
The characteristic aspects of the project can be summarized as follows.

Testing of materials and structural solutions
Initially we considered well established structural solutions that would meet the requirements of lightness and temporary, such as spatial network structures, pneumatic structures and tensile structure. However, none of these types has been found suitable to fully satisfy the requirements identified, it was therefore carried out an innovative solution that could hybridize characteristic aspects of the solutions previously identified.
The solution proposed is characterized by the use of Tensairity technology, which allows to use very lightweight and high-performance elements. These are formed by a membrane, an air chamber, tensors and struts creating an element capable of withstanding considerable flexing and compressive stresses.

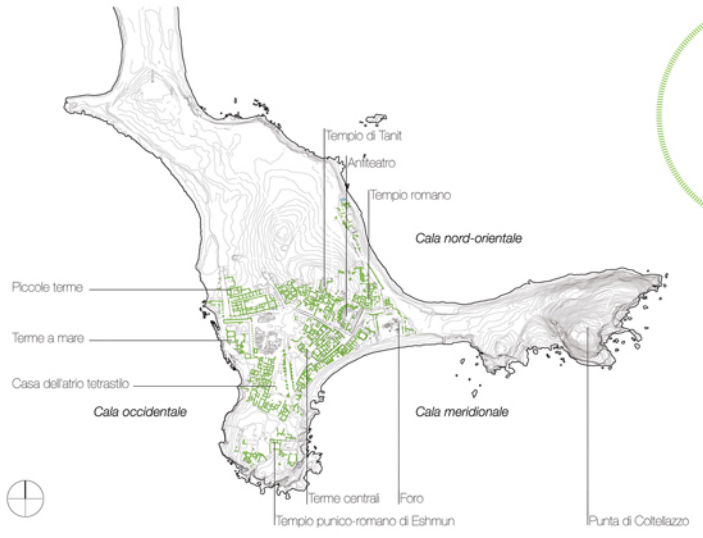
Energy self-sufficiency
Operate in an archaeological site often means having to use work tools powered by electricity. Based on an average energy demand request on the working site, and analyzing the meteorological data collected by the weather station, we were able to proceed with the design of a hybrid photovoltaic/wind turbine system to generate clean and renewable energy.

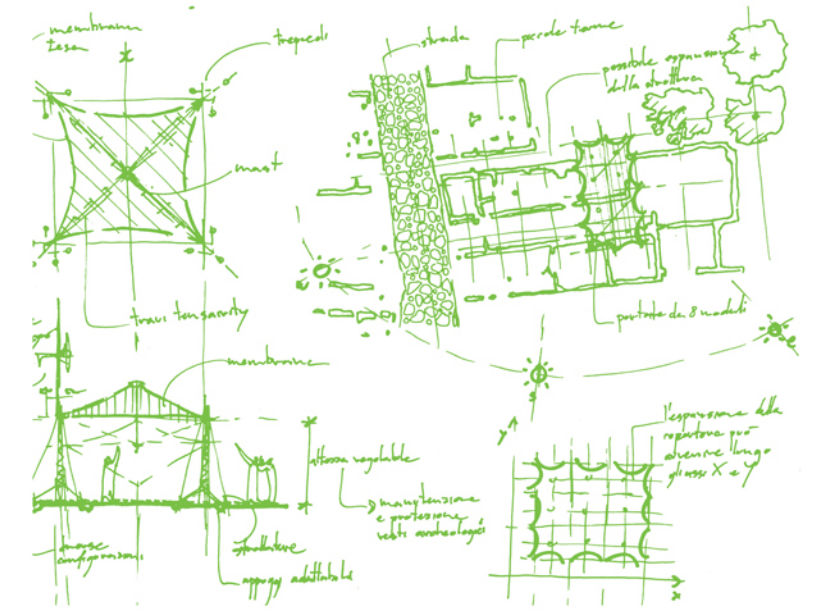
Improvable performance
The basic module is designed to provide shading in the summer and an optimum amount of natural light during the winter. We guaranteed appropriate values of solar radiation on the archaeological remains and natural ventilation. The modules provide openings that ensure adequate natural ventilation during the summer.
Besides, it was studied the possibility to implement the performance's coverage, with the addition of layers of textile easily stackable.

Disassembly and recyclability
We have finally considered the life cycle of the materials and the possibility to disassemble the components in the case of replacement or disposal. For instance, the textile material chosen for the coating coverage (Ferrari Precontraint 1202) can be entirely recycled, thus ensuring a closed loop industrial cycle.

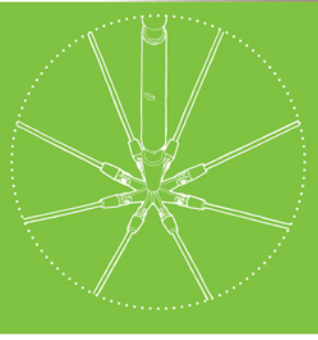
Nora archaeological site

The archaeological site of Nora is located on a promontory (Capo di Pula), close to Cagliari, in Sardinia. The project area, the 'small baths', is located in the west area of the site, near the 'seaside thermal baths' and the 'tetrastyle atrium house'. The dating of the first plant of the small baths is uncertain. Of considerable importance is the recent discovery in the small baths apodyterium of an original in-situ portion of mosaics which require interventions of conservation against deterioration due to specific environmental factors such as direct solar radiation, rain, marine aerosol, deposits and biological threats.



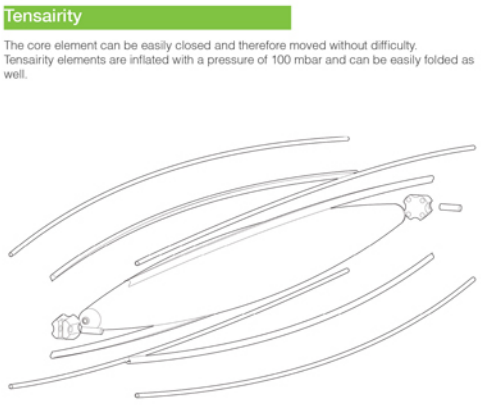


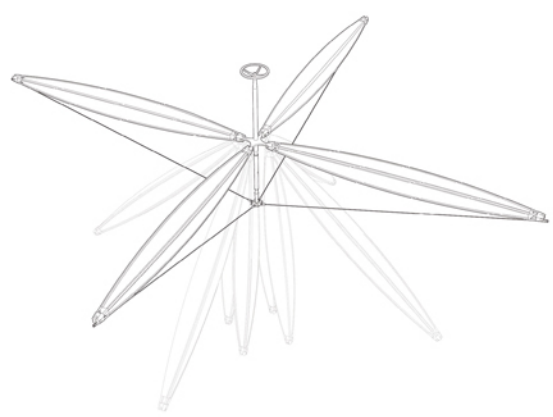
Details

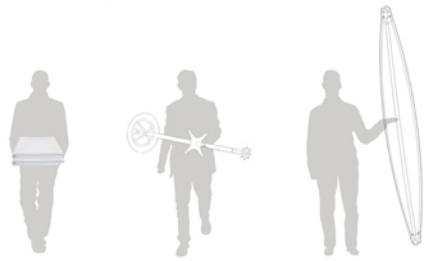


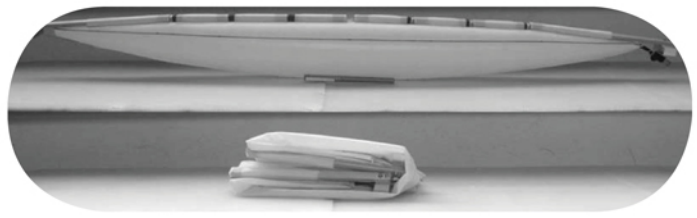
Tensairity

The core element can be easily closed and therefore moved without difficulty. Tensairity elements are inflated with a pressure of 100 mbar and can be easily folded as well.



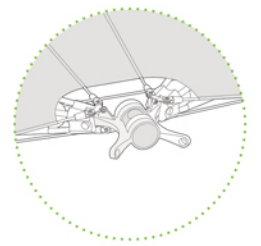


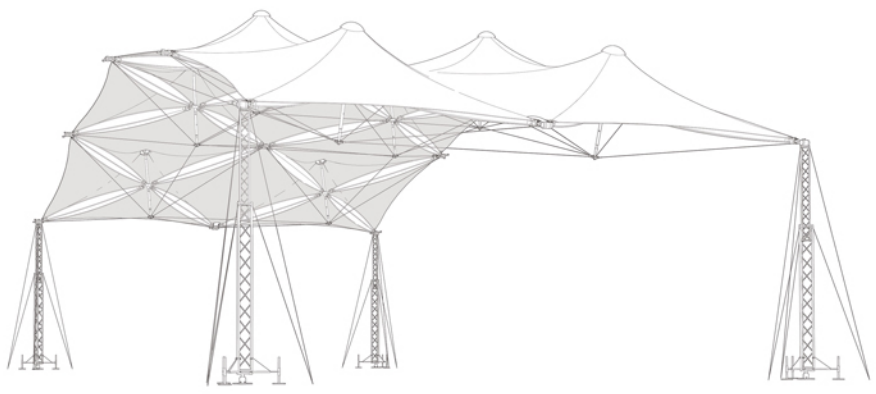


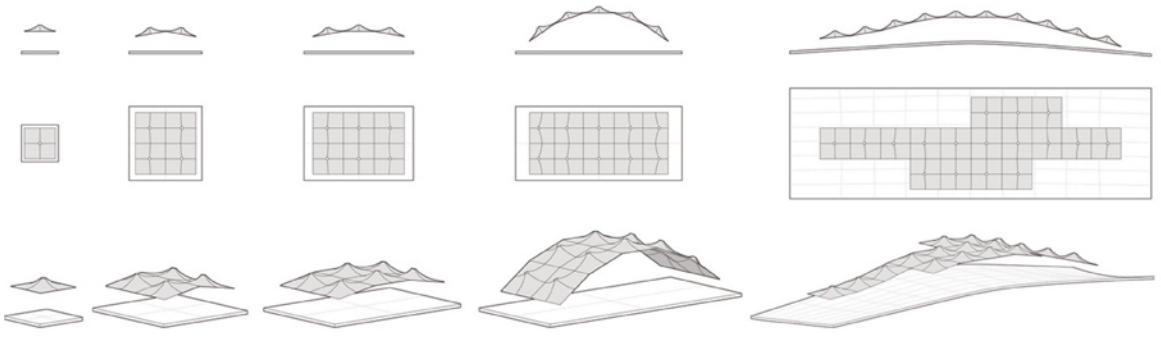


Expansibility and connections

4x2 modules configuration can be supported with the minimum amount of pillars, which can be easily secured to the tensile modules.The modular system, properly fixed with hinge connections, can adapt to many different places, following the soil conformation.







International Prize for Sustainable Architecture
2013 Competition - Degree Theses Division

10th Anniversary

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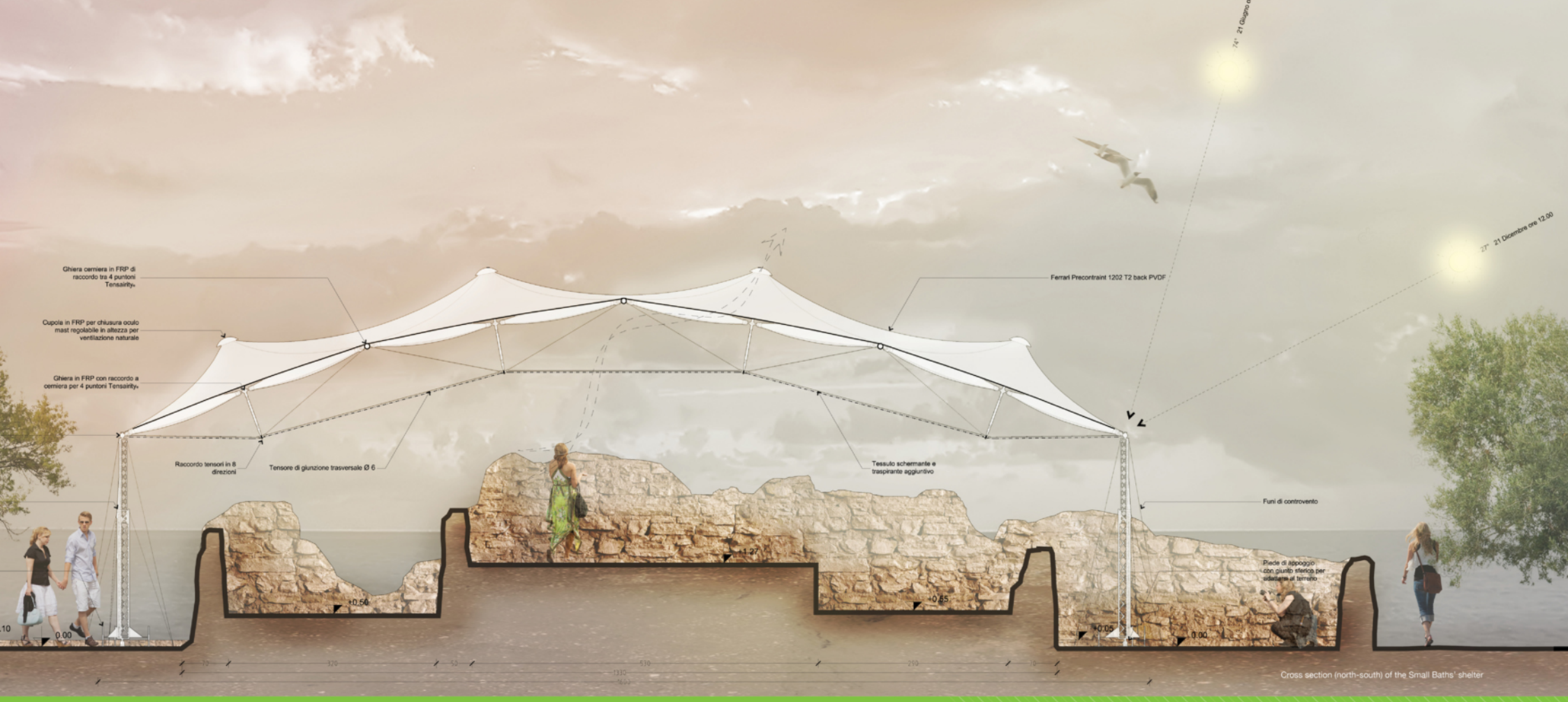
Faculty - University - Country: Sustainable Architecture - Politecnico di Milano - Italy



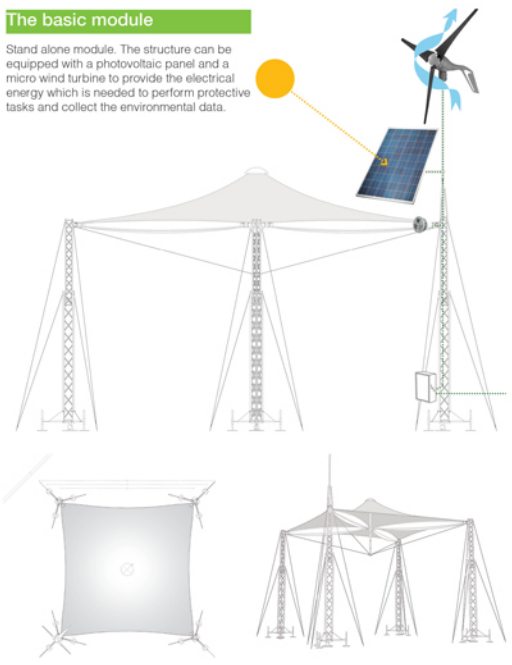
Cross section (north-south) of the Small Baths' shelter

Experimentation & innovation

Textile Architecture RESEARCH

The basic module

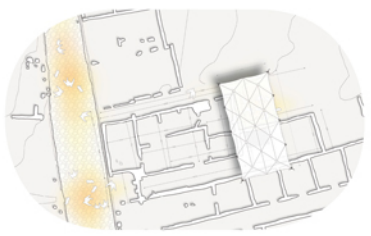
Stand alone module. The structure can be equipped with a photovoltaic panel and a micro wind turbine to provide the electrical energy which is needed to perform protective tasks and collect the environmental data.



Modularity

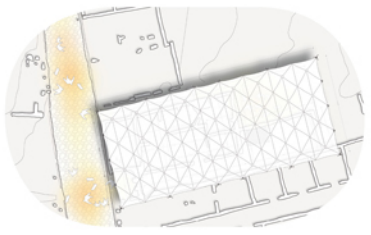
The modular design allows to expand the shelter both on x and y axes, giving the chance to extend the system step by step, as the interventions on the archaeological remains progress.

Single module configuration



2x4 modules configuration

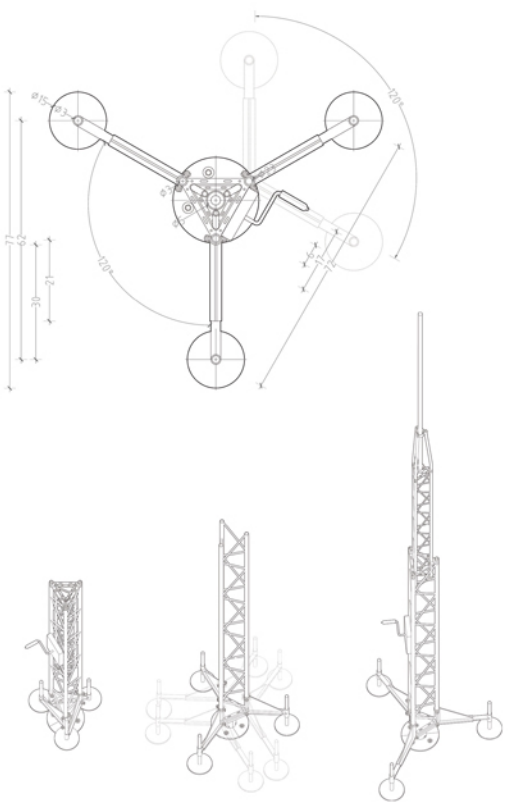
2x2 modules configuration



9x4 modules configuration

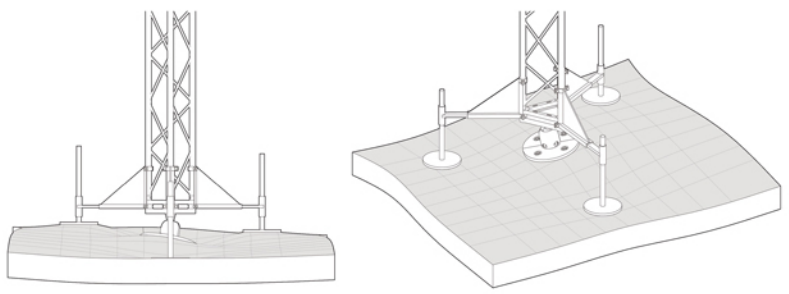
Pillars

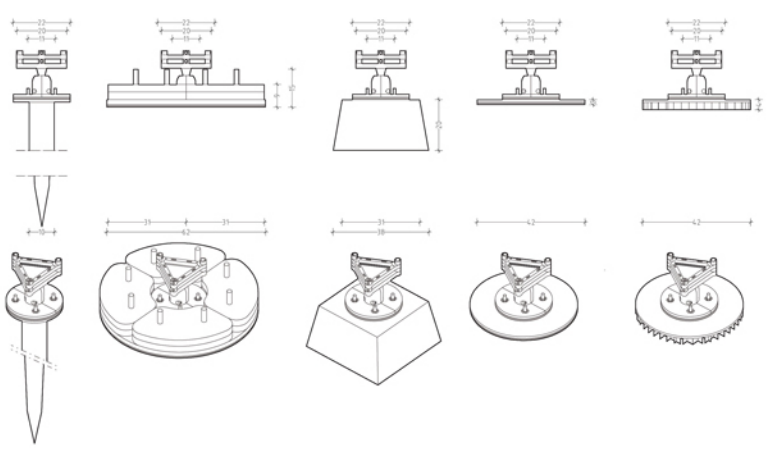
The telescopic support element is manually adjustable and allows to be retracted and therefore easily moved. The central support can be fixed through three supports which are adjustable in height and grant a rotation radius of 120 °.
In this way the support can adapt both to soil conditions and the obstacles that are almost everywhere in an archaeological site.



Lightweight basing system

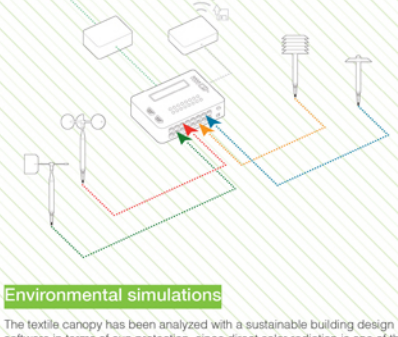
Through a set of different elements, which grants different levels of reversibility, it is possible to deal with a variety of soil conditions.
The central supporting element allows to adapt to different conditions of soil through the ball joint.





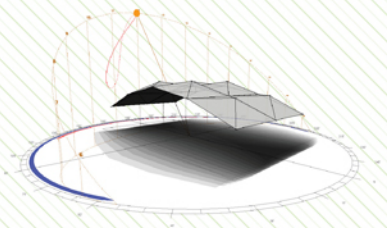
Environmental analysis

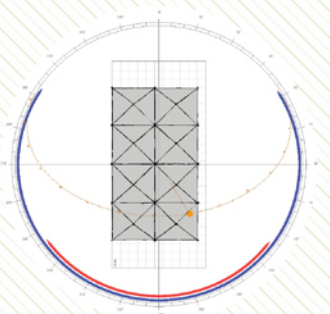
Functional diagram of the weather station that has been installed close to our project area. The environmental sensors are connected to a data logger placed in a micro station which embodies a modem for wireless transmission of data.



Environmental simulations

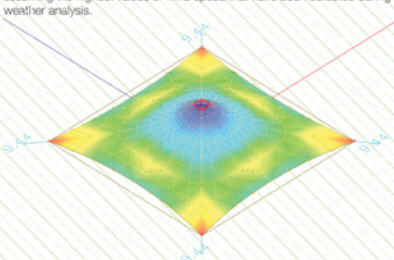
The textile canopy has been analyzed with a sustainable building design software in terms of sun protection, since direct solar radiation is one of the major factors of deterioration of archaeological remains. The analysis also ensured really high values of comfort for visitors and operators.

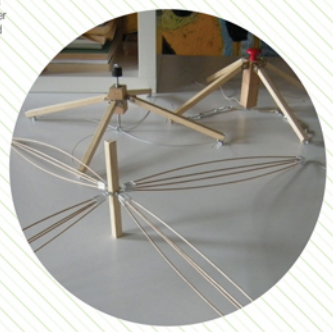




Structural analysis

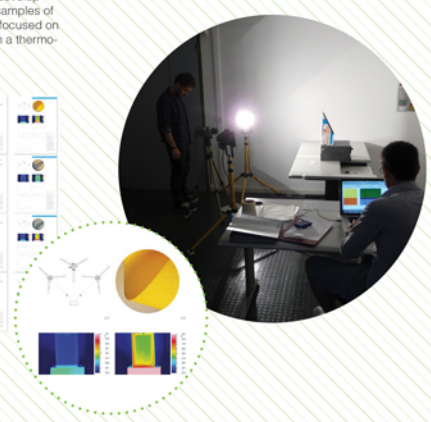
Structural properties of the protective module have been verified and studied with a specific tensile design software, ForTen 3000, with a particular attention to the upper side textile and the high strength Vectran cables. The analysis have been performed assuming the highest values of wind speed that have been detected during the weather analysis.





Experimental infrared analysis

A teamwork conservation an physics departments allowed to develop an experimental analysis method which has been used on 15 samples of architectural textiles and membranes. The analysis have been focused on heat transmission and reflection and have been performed with a thermo-graphic camera.



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