POLYTECHNIC OF TORINO
FACULTY OF ARCHITECTURE 1
Degree in Architecture
Honors theses

Conception of a suspension footbridge with numerical optimization

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The target of this Thesis was to present some guidelines for the conception and design of cable structures. The Thesis is organized into two parts: the first one deals about peculiarities of cable structures and design methodology; the second part concerns the application of the proposed method to the design of a suspension footbridge.

PART ONE

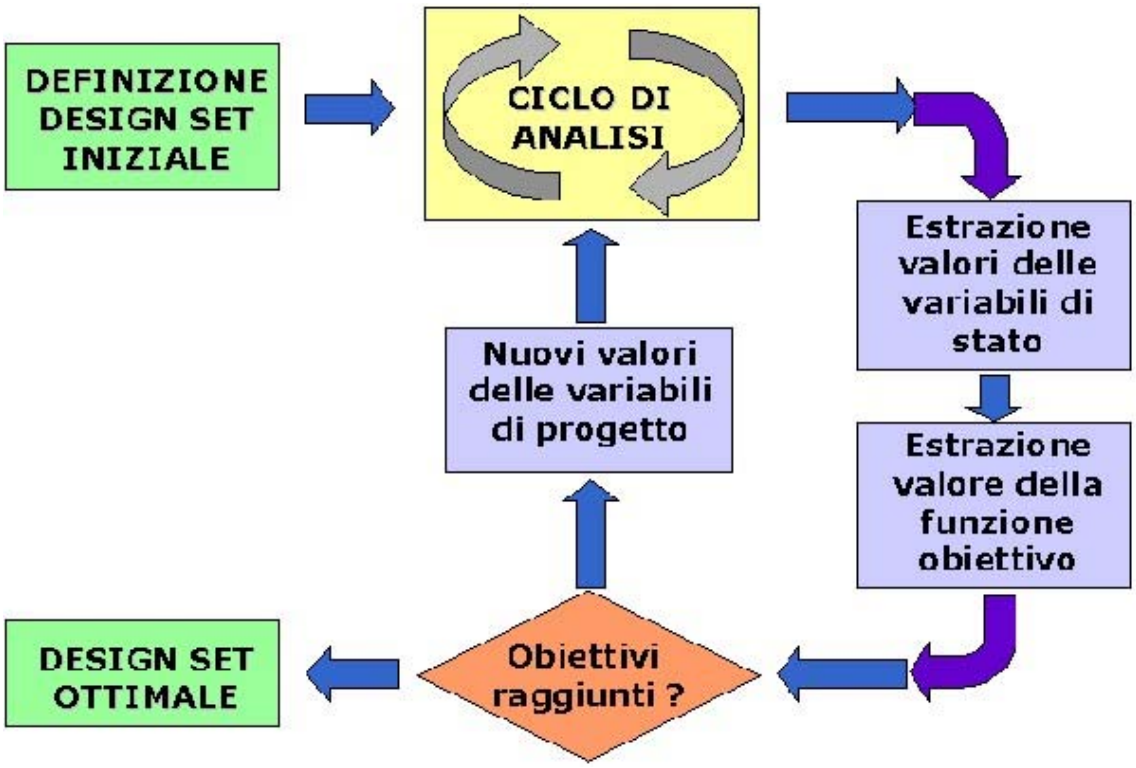
Cable structures have some mechanical peculiarities that do not allow a traditional approach towards design. Among all, the lack of flessional stiffness of the cables, that causes a great sensitivity of the structure to the applied loads. As a consequence of the close relationship between shape and structure, a preliminary step of form-finding is necessary, to find out the so called “zero configuration”, that is a particular geometry associated to a state of prestress that satisfies the equilibrium and the structural efficiency in every load condition.

The design method here presented is made of four steps:

1. Empirical instruments: building of physical models to reproduce geometry and mechanical behaviour of the structure..

2. Numerical simulation: static and dynamic analysis of non-linear finite element models, whose geometry comes from survey of the empirical model

3. Numerical optimization: process of research of the optimal design through a) the variation of design variables values, b) costraints on state and design variables, c) minimization of the objective function.

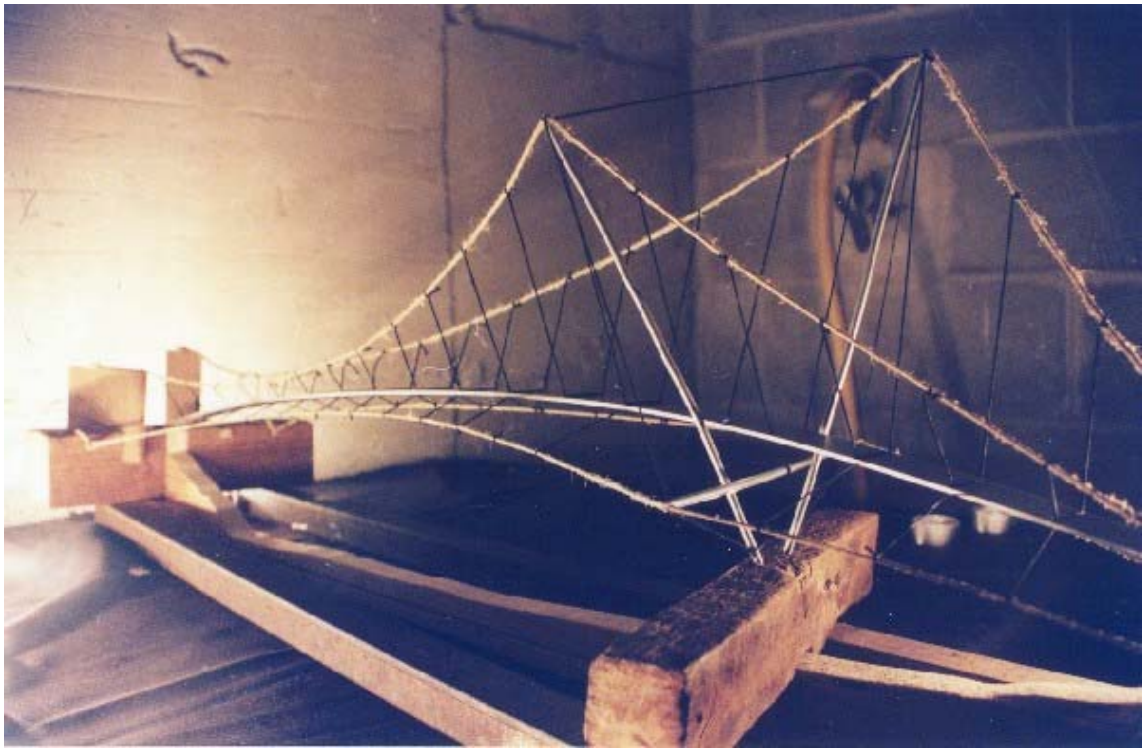


The optimization flow-chart

4. Evaluation and check of results: postprocessing, checking model response to characteristic static and dynamic loads, feedback.

PART TWO

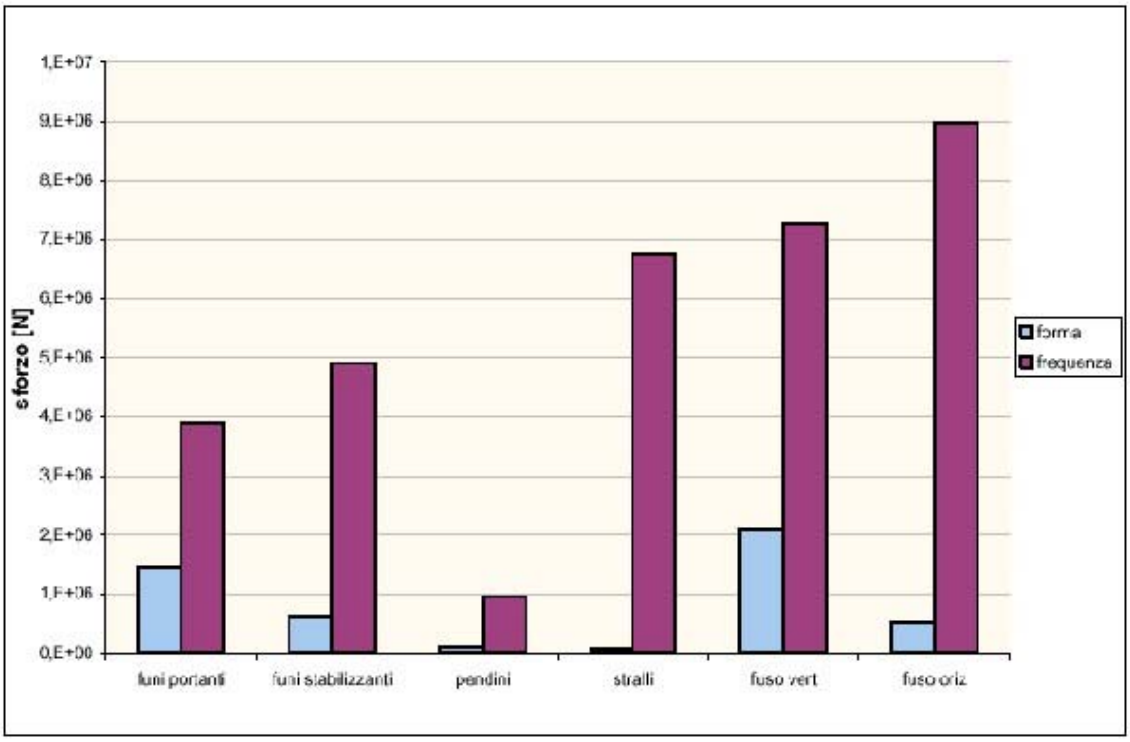
The presented method is applied to design of a cable structure. The pretext has been offered by the European Student Competition of University of Geneva “A current to cross – a link to draw. The Allobroges footbridge in Geneva”. After studying the context and the state of the art, our project arises as a cable suspended structure that includes some peculiarities reminding of tensegrity structures.



All the method steps have been accurately covered. The survey of the experimental model gave a good starting point for the mathematical model (F.E.M.).

Then the numerical optimization, the fulcrum of the whole method, has been performed twice according to two different criterions: a “shape” optimization, very careful of shape parameters, and a “structural efficiency” optimisation, more strict on structural performance.

These two optimization processes led to two different “zero configurations” that have been compared. The main difference between the two configurations lays in the value of prestresses, as can be seen in Figure 3.



Comparison between the tensional state of the two structures

The “zero configuration” of the structure optimized according to structural efficiency criterions has higher prestresses: this means that the structure is stiffer and less deployable.

This method, studied especially for cable structures, can also be applied to every kind of structure because of the flexibility of its fulcrum, the numerical optimization, and obviously considering the ever-increasing computational resources.

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