POLITECNICO DI TORINO
SECOND SCHOOL OF ARCHITECTURE
Master of Science in Architecture
Honors theses

Hierarchical space structures
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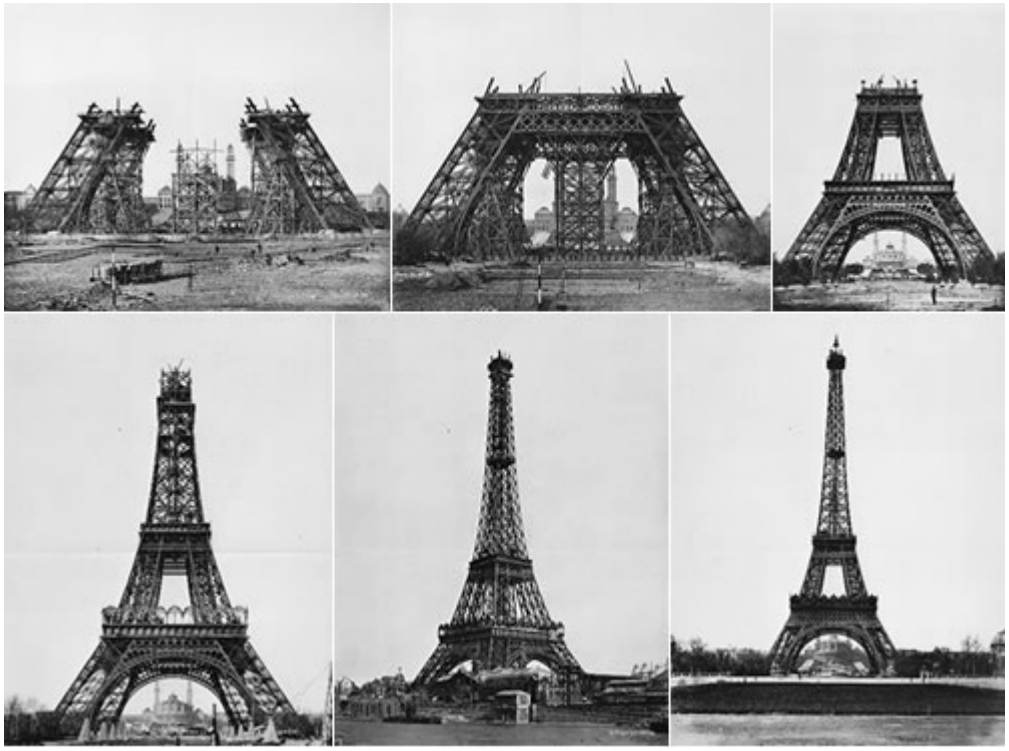
Civil Engineering Structures like bridges and footbridges waste much of their structural resources by sustaining the weight of their component material elements, diminishing their capacity of carrying accidental loads which will be loading them during their life.

The goal of this thesis is to verify the possibility of decreasing that part of loads which is represented by the dead load in order to guarantee, maintaining fixed geometrical dimensions, a better load capacity.

In order to obtain that reduction it's been used a constructing method known as "hierarchical one": structural elements, struts and ties, formed by smaller rods, unified by following a fractal design (geometrical figures characterized by an undefined sequence of figures that obey at the same construction rules with each level of hierarchy).

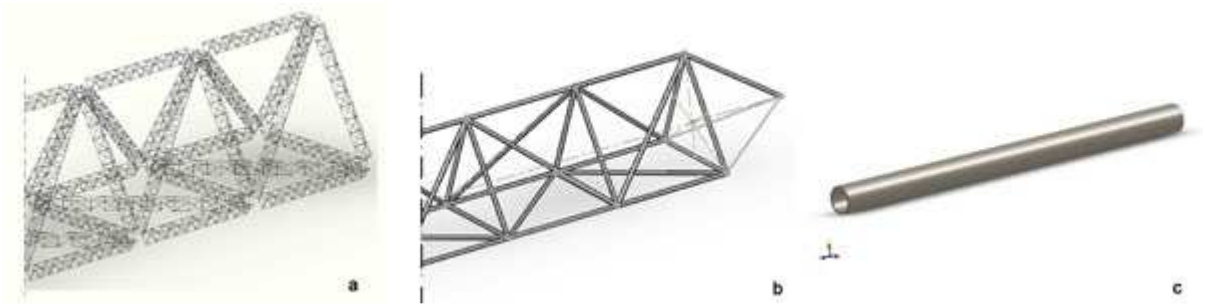


Eiffel Tower, construction stages, 1889, Paris

The most famous example of structure based on hierarchical design is Eiffel tower, built in 1889 because of universal expo.

This could be divided in three different level of hierarchy: rectangular or L-shaped cross-section bars (0^{th} order), column trusses, based on these shapes (1^{st} hierarchy), these trusses are tied together to build the legs of the tower. Each leg has a 2^{nd} order while the four legs are connected together in order to form the 3^{rd} hierarchy.

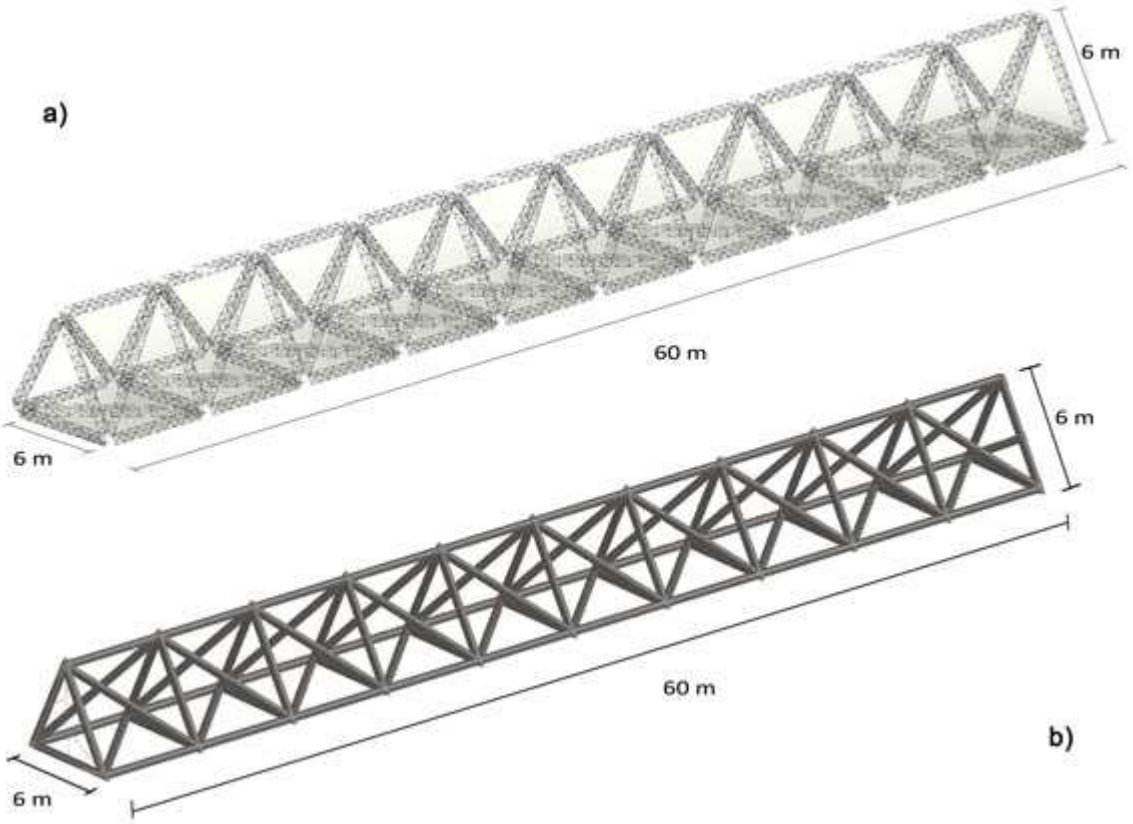
The essay published by Thomas W. Murphey and Jason D. Hinkle and titled "some performance trends in hierarchical truss Structures", in which authors discuss mechanical behavior dealing with hierarchical level increasing, has marked the 2^{nd} order like the most suitable one.



Footbridge with 2^{nd} order hierarchy; b) truss 1^{st} order hierarchy; c) 0^{th} order element

The examined footbridge has been thought as a second order structural hierarchy, and it has been calculated through an iterative procedure, which by successive approximations has led to the best physical shape. They allow increasing the accidental load, with less material used.

The footbridge configuration, conceived as hierarchy, compare with the same one without the fractal geometry, has allowed a dead load reduction on the structure of about 90%.



Footbridge with hierarchical structures 2nd order; b) Footbridge without the fractal geometry

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