

Multiobjective optimization of an architectural element steel structure

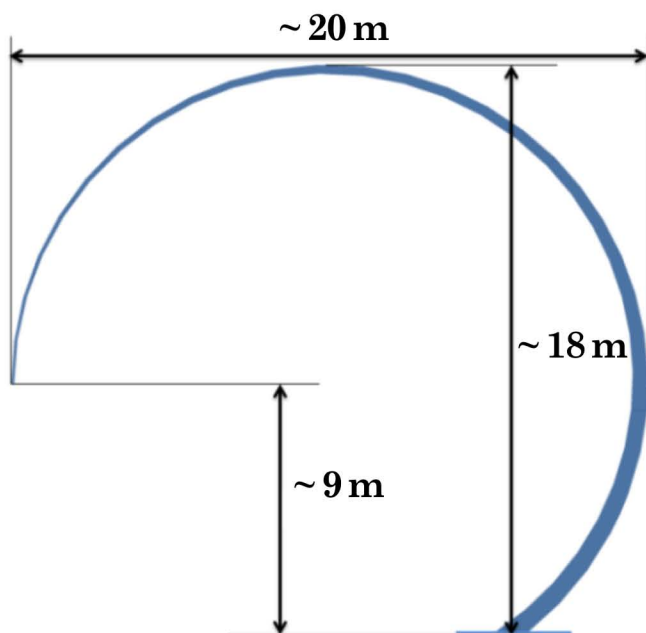
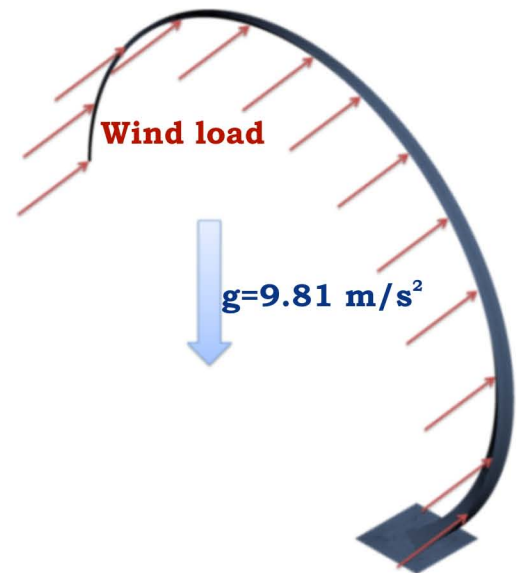
Software: ANSYS, IOSO NM

In the frameworks of the 4th international computational mechanics **CompMechWorkShop** CompMechLab engineers in collaboration with specialists of **Research Centre YTI** of Mikkeli University of Applied Sciences (Finland) and in collaboration with **Wolfgang Buttress** studio (United Kingdom) performed a multiobjective optimization of an architectural element steel structure meant for a city decorative design.



Architectural elements of city design installed in the UK area must be analyzed and manufactured according to many regulations and standards.

In particular, the steel structure of an architectural element in the considered study has been analyzed with respect to its own weight and wind load influence according to the ANSI/ASCE 7-88 and ANSI A58.1-82 international regulations.



The architectural element is a hook-shaped steel structure made of thin-walled steel profile.

The structure is 18 meters high and 20 meters wide, while the length of the "hook" arc is about 40 meters. The profile shape is chosen as an equilateral triangle.

The monument consists of five sections. The dimensions of the triangle profile are constant within each section, while they decrease by sections from the basement to the peak of the structure. The length of the triangle profile side is 1 meter at the basement and 10 cm at the peak of the structure.

In the frameworks of the considered study it was necessary to find the profile thickness values in the sections so that the mass of the structures is minimal. The minimization of the structure peak displacement under the own weight and wind load is the second optimization criterion.

The displacement of the structure more than 3.5 meters are considered to be inadmissible. The profile thickness in the sections are taken as five design variables. The following constraint is also to be taken into account: maximum stress in the structure should not exceed critical value, which is taken as 300 MPa.

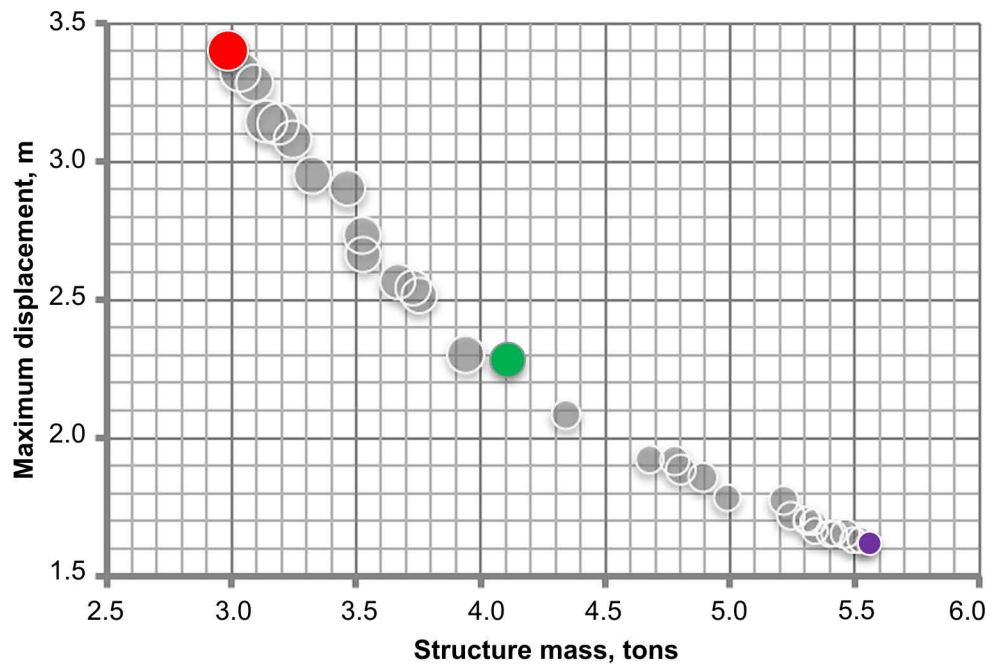
Thus the multiobjective optimization problem with five design variables, two criteria and one constraint is being solved.

The wind load is calculated according to the ANSI/ASCE 7-88 and ANSI A58.1-82 regulations for the wind speed of 31.65 m/s. A parametric model of the monument is made by FE analysis software ANSYS.

In order to fulfill the optimization an optimization code **IOSO NM** is used - a unique technology of non-linear multidimensional optimization, provided to CompMechLab by **Sigma Technology** company in the frames of partnership program.

As the result of the analysis, 33 Pareto optimal solutions were obtained in 300 iterations. These solutions can be seen in the Figure presented below.

The dimensions of the "bubbles", which represent the obtained solutions, belonging to Pareto set, correspond to maximal values of equivalent von Mises stress in the structure.



For more detailed study the following designs of the structure in the considered range of mass and peak displacement are chosen:

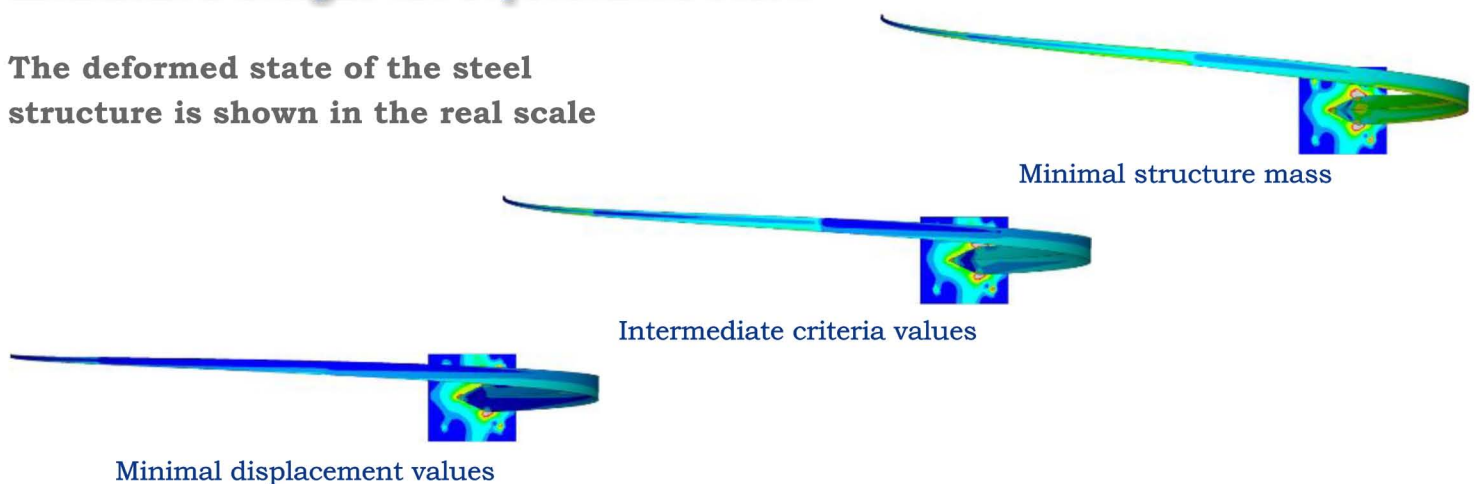
The design corresponding to **the structure minimal mass** is marked with **red** color.

The design corresponding to **the intermediate criteria values** is marked with **green** color.

The design corresponding to **the minimal structure displacement** is marked with **purple** color.

The distributions of the equivalent von Mises stress for the mentioned designs are represented below

The deformed state of the steel structure is shown in the real scale



! Hence the multiobjective optimization of the steel structure was done with the help of the program system **IOSO NM**.

● The obtained materials can be used by designers and architects for further development of the city decorative design element concept.

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