OPTIMIZATION OF MECHANICAL STRUCTURES USING INTERVAL ANALYSIS

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1 Introduction

The problem of optimal design consist in finding the optimum parameters „x" according to a prescribed optimality criterion

$$\begin{cases} \min \ J(x) \\ p(x) = 0, \ q(x) \geq 0 \end{cases} \tag{1}$$

Existing optimization methods (solon.cma.univie.ac.at/~neum/glopt, plato.la.asu.edu/guide) usually aren't reliable or can't use the nondifferentiable and not continuous objective functions or constraints. An interval global optimization method [1,3] is: very stabile and robust, universally applicable and 100% reliable. The interval algorithm guarantees that all stationary global solutions have been found.

2 Interval global optimization

The set of all closed real intervals is denoted by I(R) and the natural interval extension of a real function f(x) is denoted by $\hat{f}(.)$ [2]. The interval global optimization method is based on the properties of interval arithmetic [2]. If the following inequality holds

$$\hat{f}([x]_1) < \hat{f}([x]_2) \tag{2}$$

where $[x]_1 = [x_1^-, x_1^+]$, $[x]_2 = [x_2^-, x_2^+]$, $\hat{f}: I(R) \to I(R)$, then the global minimum is not in the interval $[x]_2$.

Several techniques are used to improve the interval global optimization algorithm for example: a midpoint test, a monotonicity test, a concavity test, an interval Newton method, a parallelization, a local minimizer, a Fritz John condition and many others.

Today exist a lot of commercial and scientific software based on the interval global optimiation method (compare cs.utep.edu/interval-comp/intsoft). Many information about interval analysis can be found on the internet (cs.utep.edu/interval-comp/main).

In order to investigate the performance of the algorithms described above a test were performed for a truss shown in Fig. 70. Using interval global optimization we can find optimal shape of this construction. In calculation we assume that bar number 1 have a constant length, L=1 m, $\sigma_0 = 190$ MPa and P=10 kN. The objective functions have the following form:

$$J = \frac{1}{\sigma_0} \sum_{i=1}^{4} |N_i| L_i \tag{3}$$

where N_i are the axial forces. The optimal results are the following: x_w=1.1895 m, y_w=0.223488 m (compare Fig.1), $A_1 = 5.493 \cdot 10^{-6}\ m^2$, $A_2 = 6.011 \cdot 10^{-6}\ m^2$,

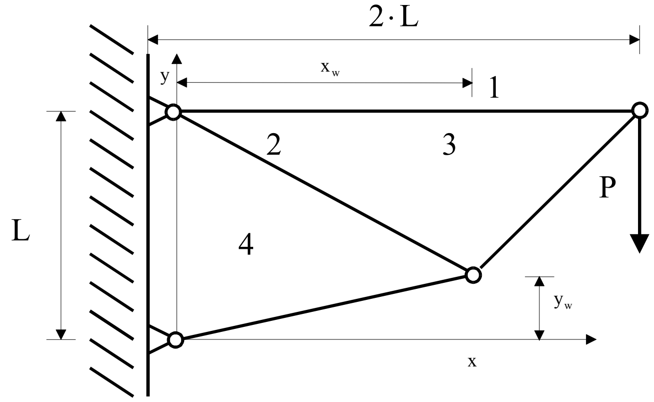

Fig. 1. Optimal shape of truss

$A_3 = 7.607 \cdot 10^{-6}\ m^2$, $A_4 = 1.071 \cdot 10^{-6}\ m^2$, where A_i are the cross sections of i-th bar.

References

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[2] MOORE R.E., 1966, *Interval Analysis*, New York, Prentice-Hall, Englewood Cliffs

[3] RATSCHEK H., ROKNE J., 1988, *New Computer Methods for Global Optimization*, New York, John Wiley & Sons

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