Abstract

The tensegrity structure concept was invented about 70 years ago. The idea has found application in many fields of science and art, also due to the attractive architectural form. Tensegrities, from the mechanical point of view, can be classified as a variety of bar-cable geometrically indeterminate spatial trusses with mechanisms that are stabilized by prestressing creating a self-stabilized internal force system. In the field of civil engineering only several structures were raised from which only few allow the use of people.

The aim of the dissertation is to study the behaviour of tensegrity structures in the design of load bearing system of towers using own numerical tools. In order to address this problem, experimental and numerical tests on a spatial T3 modules were undertaken, as well as, numerical simulations were performed. The eigenfrequencies and eigenmodes of natural vibrations were identified by the method of experimental modal analysis, as well as, the static response to axial compression was analysed on a physical model of the basic T3 module made from 3 struts and 9 cables – the Simplex equipped with strain gauge force transducers. In the part of numerical research, the T3 basic module response was tested for self-stress state and static response using three different mathematical models. These models were further used for mass optimisation with a usage of genetic algorithm. In addition, numerical simulations of five towers constructed from different modules were performed, in which elements were designed from steel circular hollow sections and systemic cables. Using own, created numerical programs, build on the experimental studies and numerical simulations, a conceptual design of a tower with a viewing platform at a height of $21\,m$ was made. A modification of a basic T3 module was used as a base for creating the tower and was optimised in terms of mass in the self-stress state. Next, the localisation of the full tower was defined, the loads were gathered and load combinations were performed, the internal forces were calculated and the bars were designed based on the limit states required in the Eurocodes. Moreover, an parametric dynamic behaviour analysis was performed, were modes and frequencies of vibrations were found.

The own-build numerical programs enabled to design the conceptual sightseeing tower with a tensegrity static scheme. The performed experimental and numerical research have given many valuable information used in the tower design process. The conducted research complements the missing experiments in the literature and fulfils at some point the lack between rich theoretical considerations about tensegrity to practical implementation in construction.

Keywords: tensegrity, towers, experimental studies, numerical studies, design, static and dynamic analysis, force density method, finite element method