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# BIOMIMETIČKE PNEUBOTSKE KONSTRUKCIJE U ARHITEKTURI RAZVOJNI MODEL MODULARNE KONSTRUKCIJE

DOKTORSKA DISERTACIJA [SAŽETAK]

## BIOMIMETIC PNEUBOTICS IN ARCHITECTURE RESEARCH MODEL FOR MODULAR STRUCTURES DOCTORAL DISSERTATION [SUMMARY]

This research explores contemporary techniques of bionic design in architecture and the resulting body of knowledge that enables the design of dynamic, adaptable and responsive structures in architecture. It constructs a theoretical platform that connects concepts from bionic design and contemporary architectural theory with concrete techniques of constructing soft robots. Ideas and concepts from contemporary architectural theory are here thoroughly analysed and processed, and investigated through a concrete model of modular pneumatically adaptable and responsive structure (pneubotics), meant for concrete architectural use.

In the introductory part, basic ideas, hypothesis, research methods and objectives are first presented, followed by an overview of modern theoretical concepts and contemporary techniques of parametric and bionic design, as well as an overview of basic pneubotic principles and design.

A broader theoretical model is then set up by means of the concept of "body plan", as it was developed by Gilles Deleuze and Felix Guattari and brought closer to architectural theory by Manuel DeLanda. "Body plan" is a plan that holds no parametric details of body parts but defines only their functional relations, as a reduced, abstract expression. As such, it is suited for translating the logic of the structure of small scale soft robots into the scale of architectural structures. The main concepts of this model include polymorphism and polytypism, the opposition of serial vs. custom production, the ideas of fold and fracture, of the virtual and the real, the idea of structure as a body analogous to natural bodies and reduced to an abstract expression, etc.

In this research, taken and investigated is the pneumatic unit in the form of a cube. This basic element is in its idea a virtual unit for construction of a multitude of structures generated from the detected body plans. A comparative analysis of collected examples of adaptable pneubotics in architecture, art and robotics is carried through the concept of structure as a body with a body plan embedded in its most abstract level. Identified basic body plans are in turn tested through physical and/or virtual model.

Two models were constructed and tested: physical model for testing structures with fewer elements ( $\leq 12$ ) and virtual model for testing structures with larger number of elements. Without going into specifics such as load bearing capacity, material properties, informational technology or robotics, qualitative analysis of various combinations of elements in a functional configuration similar to the analysed examples and their physical designs was carried out. Based on experimental tests, determined are basic features and characteristics of various types of body plans, which are then presented through possible application of these structures in architecture. Assessed are also the perspectives for further use and development of the model.

Establishing the model of bionic pneubotics in architecture introduced the possibility of use of body plans to translate structural logic of soft bodies into the field of modular pneumatically adaptive and responsive structures in architecture. It has made possible to construct structures with complex combinations of movement. Cubic form of the basic pneubotic unit proved practical for assembling structures prone to natural movement, which makes it a valid morphogenetic and morphodynamic building block for research of soft structures. Testing of the model showed that body plan, although reduced to an abstract expression, keeps the structural qualities and morphogenetic potential of original soft bodies that it is describing. Adding elements of one body plan into a structure with a different body plan can encapsulate one body plan into the other, and so the structure can inherit characteristics from both body plans.

Bringing together architectural theory, contemporary techniques of architectural design, and concepts of bionic design thus made possible to establish a model for research of their synergy through the ability of physical actualisation of several abstract phenomena. The thesis that contemporary design techniques of soft structures can expand the field of possibilities for architectural design was thus successfully confirmed, through polymorphic and morphodynamic soft structures constructed by using the basic body plans.

[Translated by author]

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■ Model pneumatske prilagodljive i reagirajuće konstrukcije postavljen je kroz ideju 'tjelesnog nacrtā' (*body plan*) kao analitičko-generativnog alata za prevođenje konstrukcije mekih robota u arhitektonske prilagodljive konstrukcije. Osnovni oblici tjelesnih nacrtā ispitani su kroz virtualni i praktični model posredstvom jediničnog pneumatskog elementa u obliku kocke što je dalo uvid u mogućnosti primjena ove vrste konstrukcija u arhitekturi kao i perspektive za daljnja istraživanja i razvoj.