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BIOMIMETIC STRUCTURAL OPTIMIZATION – TOWARDS MULTIPLE LOAD PROBLEMS

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Contemporary design methods include optimization procedures in each of the designing stages. In the case of structural design, the optimization assists engineers from the earliest design idea all the way to the end of the designing process. In the case of living entities, all kinds of the optimization must be simultaneous. An example of such a simultaneous adaptation is the phenomenon of the trabecular bone remodelling process. There are many models of bone remodelling. Most of them represent the continuation of the idea of biological regulatory process [1, 3, 4, 8]. In the regulatory model used in the paper [3], the concept of tissue adaptation is based on the homeostasis (perfect balance between bone gain and loss) assumption. This equilibrium can occur only in the presence of mechanical stimulation. The model postulates strain energy density (SED) on the surface of trabecular bone as a scalar measure of mechanical stimulation and a distinguished value of SED, corresponding to bone remodelling homeostasis. Thus, the regulatory mechanism is responsible for the remodelling process in the trabecular bone on a single cell level. But SED (as an energy measure) is also of a prime importance in optimization research, far from biomechanical applications [7]. The paper discusses some unique properties of trabecular bone functional adaptation phenomenon, useful in mechanical design. On the basis of the biological process observations and the principle of constant strain energy density on the surface of the structure, the generic structural optimization system has been developed [5, 6] and will be presented. Such approach allows fulfilling mechanical theorem for the stiffest design, comprising the optimizations of size, shape and topology [2], using the concepts known from biomechanical studies. Also the biomimetic solution of multiple load problems will be presented.

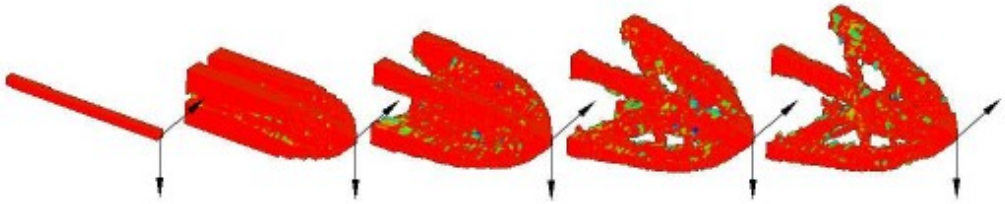

Figure 1: The optimization results of the cantilever beam bending multiple load study (altering vertical and horizontal bending force) - from the left to the right: selected simulation steps

Figure 1 depicts the results of the optimization of the standard topology optimization example - the cantilever beam bending, but including multiple load cases. The direction of the force applied was switched every two simulation steps from the vertical to horizontal one and vice versa. The solution obtained is radically different from those obtained for each of the load cases treated separatly, nor is their superposition. Due to the unique features of biomimetic structural optimization process discussed above, the evolution of the structure proceeded smoothly, despite the changes in load definition. The method allows efficient performance of the optimization process for several cases of loading, when homogenisation of SED on the surface of the structure guarantees the optimality of solution.

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