Simulation and experimental testing of concrete beams with integrated fluidic actuators

Christian KELLETER*, Timon BURGHARDT[a], Hansgeorg BINZ[a], Werner SOBEK*

*Institute for Lightweight Structures and Conceptual Design (ILEK)
Pfaffenwaldring 14, 70569 Stuttgart, Germany
christian.kelleter@ilek.uni-stuttgart.de

[a] Institute for Engineering Design and Industrial Design (IKTD)

Abstract

The rapid growth of the world population with the corresponding increase in the consumption of resources poses a challenging and essential task for the building industry. Here, especially mineral resources are being consumed at a very high rate. In some parts of the world, the availability of sand, the main ingredient of concrete, which is the most important building material in terms of mass is already limited. It is exploited at a higher rate than the natural supply can provide. [1] With the conservative construction methods and the scarcity of resources, the population of tomorrow cannot be supplied with infrastructure, living and working places sufficiently.

Adaptive structures are one way to solve this upcoming challenge. Through a smart interaction of sensors, actuators and control units, adaptive structures can react to external loads and thus reduce stresses and deformations. Especially the decisive load cases (e.g. snow, wind, earthquake), which engineers apply to design their structures, occur rarely or not at all during the service life of a load-bearing structure. Thus, most existing structures are oversized for the majority of their lifetime. On contrary adaptive structures permit a significant reduction in stresses and deformations and therefore allow significant mass savings. [2]

Previous investigations apply this concept by attaching actuators externally on load-bearing structures (e.g. moving supports) or by replacing some bars in truss structures. This method allows for an easy manipulation of the whole structure with few actuators. However, only a small number of load cases can be covered. The subproject C02 “Integrated Fluid-Actuators” of the Collaborative Research Centre SFB 1244 "Adaptive Skins and Structures for the Built Environment of Tomorrow" has the aim to integrate fluidic actuators into load bearing structures. Through a hydraulic internal pressure in the range of 40 to 300 bar, the stresses and deformations of concrete beams can be reduced. The main advantage is that this system can react to any external loads (asymmetrical point load, line load, etc.) individually - a new and promising approach, which leads to mass savings and is introduced in this article. Numerical simulations as well as experimental investigations on bending stressed concrete components with integrated fluidic actuators are presented. In the experimental investigations, adaptive structures with integrated actuators were realized for the first time, proving that the deflection can be reduced to zero despite external loading.

References

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[2] W. Sobek, “Ultra-lightweight construction”, *International Journal of Space Structures*, vol. 31, no. 1, pp. 74–80, 2016.