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Design of Integrated Fluidic Actuators for Muti-axial Loaded Structural Elements

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The construction sector is responsible for a high consumption of grey energy and a high emission of greenhouse gases. For example, the use of cement is responsible for 10% of the global anthropogenic CO_2 emissions [1]. In addition, the sizing of conventional structures is based on the most critical expected loads or load combinations that rarely or even never occur. Therefore, today's conventional structures are oversized for most of their lifetime.

By integrating actuators, sensors and control units into the structure, the structure can adapt to external loads and reduce stresses and deformations. So, these adaptive structures allow to counteract this oversizing. Therefore, the structure can be built with less material. [2]

A structure can be adapted by internal or external actuation. Due to the high static indeterminacy of two-way slabs, both actuation concepts have locally limited effects. For example, manipulation via the edges cannot react as well to loads in the centre of the slab as an internal actuation. In slabs, especially asymmetric changing loads require local adaptation of the structural element. A promising approach for the local actuation of structural elements subjected to bending stress is the integration of actuators into the cross-section of the element. For this specific task, the use of fluidic actuators is a suitable solution due to their high energy density. Within the subproject 'C02' of the CRC 1244, actuators were developed for the integration into the pressure zone of a beam. By applying forces in the longitudinal direction of the beam, a moment is generated that counteracts the bending moment caused by the external load. The functional capability could be proven by simulations and experiments [3]. New challenges arise in the actuation of slabs due to the multi-axial load transfer. Many actuator principles are conceivable for this application. The possibilities span from the combination of uniaxially acting actuators to complex designs that generate forces in different spatial directions in a targeted manner. This contribution presents different actuator principles for the development of structure integrated actuators for the generation of multi-axial load conditions. For this purpose, the actuator principles are structured according to various aspects. In a second step, numerical investigations are used to prove the effectiveness of the actuator principles.

REFERENCES

[1] K. Scrivener, V. John, E. Gartner. Eco-efficient cements: Potential economically viable solutions for a low-CO_2 cement-based materials industry, *Cement and Concrete Research*. 2018.

[2] W. Sobek. Ultra-lightweight construction. *International Journal of Space Structures*, Vol. 31, pp. 74-80, 2016.

[3] C. Kelleter, T. Burghardt, H. Binz, L. Blandini, W. Sobek. Adaptive Concrete Beams Equipped with Integrated Fluidic Actuators, *Frontiers in Build Environment* 6, 2020.