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Effective range of integrated fluidic actuators in structural elements

Matthias J. Bosch[1*], Markus Nitzlader[2], Timon Burghardt[1], Matthias Bachmann[1], Hansgeorg Binz[1], Lucio Blandini[2] and Matthias Kreimeyer[1]

[1] Institute for Engineering Design and Industrial Design (IKTD), University of Stuttgart, Pfaffenwaldring 9 – 70569 Stuttgart, Germany, matthias.bosch@iktd.uni-stuttgart.de
[2] Institute for Lightweight Structures and Conceptual Design (ILEK), University of Stuttgart, Pfaffenwaldring 14 – 70569 Stuttgart, Germany, markus.nitzlader@ilek.uni-stuttgart.de

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A high demand for living and working space as well as the corresponding infrastructure, caused by a growing population and increasing prosperity worldwide, leads to an increased consumption of mineral resources. This is accompanied by a high usage of grey energy and a high output of greenhouse gas emissions. For example, the cement production is responsible for up to 10 % of global anthropogenic CO_2 emissions [1]. In addition, the design of conventional building structures must be based on relatively high loads or load combinations that rarely or even never occur. Thus, today's conventional structures are oversized for most of their lifetime.

Adaptive structures represent a promising approach for mass and resource savings. Through the interaction of actuators, sensors and control units, the structure can adapt to the external loads to reduce stresses and deformations. As a result, material input can be reduced. [2]

In order to respond to all possible load cases, the structural element has to be manipulated locally. For structural elements subjected to bending loads, it is advantageous to integrate actuators into their cross-section to optimize the load transfer and thus achieve material savings. Fluidic actuators are a suitable solution due to their high energy density. However, they must be designed for this application. This is part of the subproject ‘C02’ of the Collaborative Research Centre 1244. The functional capability has been demonstrated for beams made of concrete in various simulations and on functional samples [3]. Therefore, actuators were integrated into the compressive zone of the 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 effective range of the generated moment is limited, since the force is directly short-circuited via the concrete surrounding the actuator. For actuators in slabs, new challenges arise due to the multi-axial load transfer. In particular, the aim is to achieve the largest possible effective range of the applied moment in order to reduce the number of integrated actuators required. One approach is to optimize the geometry of the force-introducing surfaces inside the structural element.

This contribution presents a study about the correlations of the geometric parameters. Here, numerical simulations are used to determine these correlations. Based on the results, an analytical approach is formulated that describes the impact and area of influence of the intra-structural force application. Thus, the geometric and mechanical interface between the structural element and the integrated actuator can be pre-dimensioned. A first step towards the design of an adaptive element with integrated actuators subjected to bending is hereby possible.

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