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Actuation of concrete slabs under bending with integrated fluidic actuators

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In previous researches it has been shown that 33 % to 44 % of the mass in residential and office buildings and up to 50 % in high-rise buildings is attributable to floor slabs [1, 2]. Floor slabs typically take loading through bending. Such a load-transfer mechanism is not efficient, since the material in the proximity of the neutral plane is practically unloaded thus resulting in a poor utilization rate. Since bending stiffness is significantly lower than axial stiffness in a slab, typically deflection limits under out-of-plane loading govern the design of floor slabs. This causes significant oversizing. In addition, structures are typically oversized since they are designed to take extreme loading events, which in practice occur only for a small part of the service time. The on-going climate crisis, the expected world population growth and associated resource scarcity, call for new methods and solutions to build material-efficient structures with low embedded greenhouse gas emissions [3]. Employing adaptive structures could provide solutions. By integrating structures with components such as sensors, actuators and control units – stress and deformation caused by changing loads can be reduced actively, which enables significant material savings [4, 5]. Previous work carried out at the University of Stuttgart within the Collaborative Research Center 1244 has demonstrated that it is possible to compensate deflections by integrating fluidic actuators in beam structures subjected to bending [6]. However, it is not obvious how to transfer actuation strategies employed in beams to floor slabs due to multi-axial behaviour. In this work fluidic actuators are strategically integrated into floor slabs to employ multi-axial force transfer to counteract the effect of out-of-plane loading. The research also addresses the choice of an optimal distribution and layout of the actuators. Numerical simulations of different actuation strategies, such as uniaxial and biaxial actuation have been carried to derive influence fields. The relationship between principal moments and the influence of actuation is quantified numerically. Examples are provided to show how influence fields can be employed to select suitable actuation strategies. Results show that displacements can be efficiently compensated through a combination of uniaxial and biaxial actuation.

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