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Potentials of 3D Printing Technique in Optimum Design of Reinforced-Concrete Elements

A. Baghdadi*, C.Müller, H. Kloft

* TU Braunschweig Inst. für Tragwerksentwurf
Pockelsstrasse 38106 Braunschweig. Email:a.baghdadi@tu-braunschweig.de

Abstract
This paper discusses the potentials of the steel printing-technique, in the construction industry. This study, enjoys the robotic manufacturing, topology optimization and structural science toward a new constructi-on approach. Wire and Arc Additive Manufacturing (WAAM) enables the designer to cast Free-Form-Bar (FFB) in place as reinforcement and/or anchor inside of the concrete in optimum shapes. The optimized shapes of FFB can improve the stress-distribution in the concrete and force-transmission in the steel. This technique can be used to form the embedded FFB in the concrete, which can also be welded to the external steel attachments, e.g. steel connector plates on the surfaces of the concrete elements. The FFB are ordinated parallel to the principal stress to improve the efficiency of the elements, and/or as stirrup-rebar against shear cracks. Additionally, WAAM can be utilized to form embedded cages of the bar to confine concrete and ensure the bars remain firmly anchored in a field with continua properties. The targets of this optimized printing-technique are increasing the stiffness of whole geometry, having uniform stress distribution in the concrete, increasing integrity and minimizing material. In this optimization, the variables include the shape, the location and the dimensions of the embedded FFB. The selected tools for these assessments include FE simulations, structural calculation methods and experimental tests. The study develops and proposes optimal printable patterns by simultaneous FE analysis and topology optimization. The optimization and printing method are described and the accuracy of the analysis proved by experimental tests. The comparison of a common T-shape element with the optimized root-shape FFB elements indicates that the amount of stress and the stiffness of the connector can be modified up to 35%.

Keywords
Printing Technique, Free Form Bar, Stress Distribution, FE-Analysis, Concrete Elements, Optimization.