3D WOVEN CELLULAR STRUCTURES AS CONTINUOUS REINFORCEMENT IN CEMENT-BASED COMPOSITES SUBJECTED TO IMPACT LOADING

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ABSTRACT

Beside numerous advantages, existing concrete and steel reinforced concrete are extremely vulnerable against short-term dynamic loadings such as shock, collision or explosion. This is primarily caused by a low tensile strength as well as pronounced brittleness of conventional concrete structures. With regard to impact loading scenarios, a promising approach to improve damage tolerance of available concrete members consists in applying flat, thin strengthening layers made of cement-based composites having ductile failure behavior. Among others, reinforcing structure is a key constituent component that can enhance structural mechanical properties as well as enables elastic load bearing capacity of such high performance composites, providing sufficient protection against impact. This paper investigates the potential and behaviors of 3D woven cellular structures as a novel class of textile reinforcement applied to cement-based composites subjected to impact loading. These are truss-like architectures with fine cells, having specific inherent good load bearing capability. Advanced manufacturing technology is the highlight of such reinforcement. Using weaving technology, complex 3D cellular structures can be fabricated in an automated, one-stage process. Customizing mechanical properties of attained structures is possible by varying structural parameters and combining appropriate materials during weaving. One focus of the paper is designing and technological solutions for the manufacture of a variety of 3D woven cellular structures that have great potential for improving the performance of reinforced cement-based composite subjected to impact loading. Another focus is experimental investigation of the behavior of 3D woven cellular structures when being used as reinforcement in cement-based composites under different loading rates. The experiments are conducted from single yarn to composites to enable a comprehensive performance analysis from material to structural level. The results show that 3D woven cellular structures are well processable in different cementitious matrices and help to enhance their load bearing as well as energy absorption capacity significantly. Attained performance is strongly affected by applied 3D configuration. The influence of different structural parameters are determined through the test series, establishing an effective design concept of 3D woven cellular reinforcing structures for cement-based composite subjected to impact. Based on the gained knowledge, further structure and technology developments regarding the fabrication of 3D woven cellular structures are proposed with the aim to achieve a sufficient, industrial adoptable strengthening system for existing concrete constructions in impact loading scenarios.