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Steel Fiber Reinforced Concrete Under Concentrated Load

by

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Abstract

The situation of high compressive load transmitted onto limited area of concrete member occurs frequently in a variety of industrial and engineering structures. Hence, numerous investigations have been conducted in the past to study the behavior of concrete under such loading, but mostly of plain and conventionally reinforced concretes. With the increasingly widespread use of steel fibers in the field of structural application, it is therefore of great interest to investigate the performance of steel fiber reinforced concrete (SFRC) subjected to concentrated load.

The objective of the present PhD thesis was to characterize the load-bearing and fracture behavior of SFRC under concentrated loading (i.e. point loading) by means of experimental approach. Based on an extensive literature survey, a comprehensive experimental program containing both non-fiber-related and fiber-related parameters has been proposed and performed under laboratory conditions. The non-fiber-related variables commonly influencing the structural behavior of plain concrete included concrete compressive strength, specimen dimension, area ratio and eccentricity of load. The fiber-related factors specifically affecting the mechanical properties of SFRC included fiber properties (e.g. strength, dimension, geometry and aspect ratio), fiber content and orientation, combination of different fiber types (i.e. hybrid fiber reinforcement). In addition, hybrid concrete systems consisting of both plain and fiber concretes have been produced and tested under the same conditions. The effect of these parameters on the maximum local compressive stress, the stress versus displacement (or deformation) response as well as the failure and crack characteristics of concrete specimens have been presented and evaluated.

Based on the experimental results, it can be concluded that the presence of steel fibers substantially improved the load-bearing behavior of concrete under concentrated load and changed the failure mode of concrete from a brittle to a ductile one. Such improvements could be attained even by incorporating a thin layer of fiber reinforcement as observed in the case of hybrid concrete system. The positive effect of steel fiber on the maximum load-bearing capacity and the post-cracking ductility increased notably with the increase of tensile strength, dimension and content of steel fiber, and thickness of fiber reinforcement layer as well as by using optimized hybrid fiber reinforcement. Generally, the reinforcing effectiveness of steel fibers tended to reduce progressively with decreasing area ratio or with increasing eccentricity of load and specimen dimension. A higher concrete strength led to higher maximum load-bearing capacity, but less ductile post-cracking behavior. The aforementioned benefits provided by steel fiber could, however, only be guaranteed on the condition that a favorable and uniform fiber orientation towards the directions of the acting tensile stresses existed in the SFRC specimen. Moreover, the fiber orientation could be most significantly affected by the casting direction.

The findings acquired here can be used as fundamental information for the composition and optimization of SFRC mixtures, the production of SFRC concrete elements as well as for the constructive design and practical application of SFRC structural members exposed to concentrated load.

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