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MULTI-SCALE PROBABILISTIC MODELING OF GLASS FIBER REINFORCED CONCRETE

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Summary: Glass fiber reinforced concrete (GFRC or GRC) has been increasingly applied in civil engineering practice throughout the 21. century. The short dispersed AR-glass fibers increase the cracking strength, ultimate tensile strength and toughness of the cementitious matrix. Each fiber consists of several hundreds of filaments which are bonded together by a sizing. The composite allows for form flexibility, material savings, increased durability and high compressive and tensile strength. These features make the use of GFRC an environmental feasible alternative to traditional steel reinforced concrete in some application domains.
Once a crack has formed in the matrix, fibers bridging the crack act against further crack opening by stretching and pullout. The evaluation of the bridging force due to reinforcing fibers is the subject of the present paper.
GFRC exhibits a number of sources of randomness that can be divided into three scales:
1) At the micro scale, individual filaments within a bundle are considered. The fibers are assumed to have a random bond stress depending on their position within the bundle and thus on the penetration of the matrix into the bundle core. Another source of randomness at the micro level is the fiber strength.
2) At the meso scale, individual bridging fibers have a random orientation and embedded length.
3) At the macro scale, the overall number of fibers bridging a crack is a random variable that depends on the specimen geometry, fiber geometry and fiber volume fraction.
These three scales of randomness are combined in a probabilistic multi-scale model that is capable of predicting statistical moments of the bridging force given the material a geometrical parameters and the distribution of the random parameters. The model allows for probabilistic design of GFRC and is able to predict various sources of statistical size-effects.