

About Possibility to Predict Fibers Orientation and Distribution in Viscous Flow

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Short fibers as reinforcement are used in many structural applications in aerospace, automotive, machine building and civil engineering industries. Important part of fabrication technologies for such materials is based on structural element mould filling by liquid matrix with short fibers. Traditionally the matrix is viscous (polymers, fresh concrete). After maturing and demolding structural element mechanical properties are highly dependent on fiber distribution and orientation in the element body. For example, polymer matrix composite with short glass fibers or steel fiber reinforced concrete post cracking behavior and load-bearing capacity are dependent on the number of fibers crossing the weakest crack (bridged the crack) and their orientation to the crack surface [1-3]. This is why it is important to investigate this process.



Fig. 1. Large container experimental equipment for fibers flow mechanics investigation.

Single fiber motions in viscous flow as well as fibers' set motion in the flow with velocity gradient were investigated experimentally and numerically. Single fiber motion in viscous flow with velocity gradient was modeled experimentally using a small container and a large container (see Fig.1) as experimental equipment. In both cases model

liquids - potato-starch solution and glycerin - fluid with known viscosity parameters (measured experimentally) were used. Viscosity coefficient values were obtained experimentally by dropping metal ball method. In experiments with small container liquid was poured into the transparent container. Single steel 50 mm long and 1mm in diameter fiber was inserted in the container middle part (with fluid) under the different starting angle to the vertical axis. In initial position the container was placed fully horizontally. Then container was turned sideways from the horizontal position for required angle α and test started. Fiber position and declination angle β at every time moment are influenced by the movement of the fluid. Movement of the fiber in the fluid was recorded by video-camera with a timer. In experiments with large container a) single fiber; b) 8, 12, 16, 30, 100 fibers were placed at different places in large container, after that container was turned sideways from the horizontal position for required angle. Movement of the fiber in the fluid was recorded by video-camera with a timer till the movement end when fiber with liquid from horizontal container is filling second bottom container which is modeling the mould. Flow numerical simulation was realized using computer program

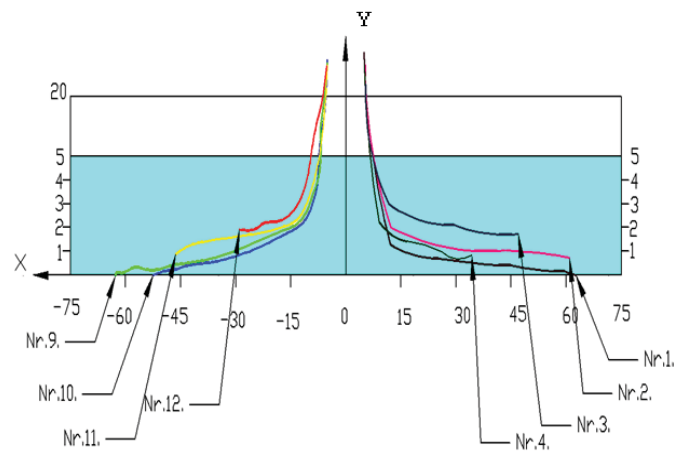


Fig. 2. Selected fibers trajectories in the flow (in the container modeling the mould) in the case when 12 fibers were at starting position located by pairs symmetrically in upper container.

FLOW-3D (see Fig.2). In the case of one fiber numerical simulations results were compared with experiments and calculations were made using Jeffery formulae. In the case of 100 fibers numerical simulations were done for steel fibers in concrete. Obtained fibers location and orientation predictions were used for fiberconcrete beams mechanical behavior simulation under 4-point loading conditions (including behavior under intensive cracking). Simulation results were compared with realized mechanical experiments.