

# POLYMER FIBER PULL OUT EXPERIMENTAL INVESTIGATION

Vitalijs Lasis, M.sc.ing., Arturs Macanovskis, M.sc.ing., Andrejs Krasnikovs, Dr.sc.ing.  
Riga Technical University  
Address: 1 Kalku Street, LV-1658, Riga, Latvia  
Phone: +371 67089159  
e-mail: Vitalijs.Lasis@rtu.lv, artursmacanovskis@inbox.lv, Krasnikovs.Andrejs@gmail.com

Advanced polymer fibers are used in structural applications as micro reinforcement in composite materials with concrete matrix. Comparing to another fibers (steel, glass, carbon etc.) polymer fibers are behaving visco-elastically or visco-elasto-plastically. Such fibers have relatively not high starting elastic modulus are characterized by relatively large elastic deformations and pronounced Poisson's effect during stretching. Concrete prisms 10x10x40cm were fabricated contained different amount of 3cm long 0,75mm in diameter polymer fibers. All prisms were tested under 4 point bending conditions and loading velocity  $v= 150\text{N/s}$ . First peak on the load – deflection curves corresponds to macro crack formation (in the weakest prism crosssection) and splitting the tensioned part of the bended prism crosssection. Beam midpoint vertical deflection is reaching tenth part of mm, fibers in material aren't loaded. After that fibers in crosssection start to stretch. Debonding is growing (bond is weak and each fiber Poisson contraction is high) reaching the length dependent on each particular fiber orientation to crack surface. All fibers bridging the crack are stretched (load is increasing- second peak on the curves). After that fibers start to rupture and its ends with friction are pulling out (curves after second peak). Relatively low polymer material Young modulus is leading to two peaks formation on the curves what wasn't recognized for materials with high modulus fibers. Single polymer fiber is embedded into elastic matrix and was subjected to external applied pulling load was numerically simulated. Numerical modeling was performed using 3D FEM approach. Relaxation effect was neglected and was supposed that fiber is deforming elastically. Experimental data analysis shown that the pull-out process can be divided into three stages- a) fiber pull-out with perfect bond between fiber and concrete matrix; b) fiber pull-out with partial debond (cylindrical crack) between concrete matrix and fiber, started from concrete matrix surface; c) fully debonded fiber pull-out of concrete matrix. Simultaneously simplified shear-lag analytical model (improving approach observed in Hutchinson et al., 1990) was elaborated and executed. Simulations results were compared with performed pull out experiments. Comparison was allowed to obtain numerical values for micromechanical process- friction coefficients on the fiber/matrix interface during fiber sliding motion with friction out of concrete matrix. The results of the numerical modeling were compared with experimental data and were discussed.

## References

Hutchinson J.W. and Jensen H.M. (1990) Models of fibre debonding and pullout in brittle composites with friction. *Mechanics of Materials*, No 9, pp 139-163.