

Tetsu Uesaka

“Non-affine Deformation of Fibre Network: The Origin of Stiffening and Softening”

A fibre network is a ubiquitous structure, which is seen in the cytoskeleton in plant and animal cells, paper, nonwoven, and their composites. These structures are generally highly disordered, and thus their deformations are not “affine”, that is, local strains are not equal to macroscopic strains (non-affine). In this talk, we take an example of a paper fibre network and investigate non-affine deformation fields in the fibre scale by using a Discrete Element Method (DEM). With the DEM, fibres are represented by a series of connected spherical particles (“beads”). The bead-bead interactions, within a fibre and between fibres, are represented by forces and moments in stretching, shear, bending and twisting. Non-affine deformation is a result of the system’s attempt to minimise its total strain energy. Therefore, the system tends to settle in the lower-energy modes of deformation, such as bending and twisting over stretching. An astonishing feature is that only a few fibres carry the most strain energy or forces, whereas the majority of fibres almost “rest”. Therefore, the peak of the distribution of strain energy of individual fibres resided very close to zero. The implications of these results is discussed in relation to the stiffening and softening phenomena of the fibre network.



Tetsu Uesaka was a professor at Mid Sweden University and retired in 2017. His area of research interest is (still) complex systems found in fibre networks, complex fluids, and also in biological and social systems. He received his doctoral degree from Kyoto University in 1980 and spent two years at the State University of New York as a postdoctoral fellow. In 1982, he joined Oji Paper Company in Tokyo, where he learned and enjoyed problem-solving encountered in new product development and paper machine operation. In 1988 he moved to Montreal to work for Pulp and Paper Research Institute of Canada (PAPRICAN). He started as a research scientist, and then later joined its senior management team. In 2003 he took the professorship at Mid Sweden University. His honors include a J. A. Van den Akker award (2003, 2007 and 2018), together with his colleagues and students.