6th European Conference on Computational Mechanics (Solids, Structures and Coupled Problems) (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
June 11- 15, 2018, Glasgow, UK

VISCOELASTIC PROPERTIES OF FIBRE-NETWORK MATERIALS

XIUDE LIN, YUIHUI MA, HANXING ZHU*

School of Engineering, Cardiff University, Cardiff, CF24 3AA, UK
* E-mail: Zhuh3@cf.ac.uk
https://www.cardiff.ac.uk/people/view/364504-zhu-han-xing

Key words: Fibre-network materials; Collagen; Transversely isotropic; Viscoelastic properties; Stress relaxation.

ABSTRACT

Fibre-network materials are widely used as scaffold/substrate for load bearing and other physical and chemical supports in biomedical engineering. One of the most widely used proteins to construct the fibre-network materials is collagen [1]. Collagen composes fibres and fibres intersect mutually to form the network. It has been found that the mechanical properties of tissues are mainly dependent on those of the fibre-network scaffold/substrate. Therefore, three-dimensional beam models of transversely isotropic stochastic fibre-network materials with cross-linkers and different relative densities have been generated for the finite element analysis of mechanical properties [2], where major attention is paid to the viscoelasticity of the collagen fibrous network. Stress relaxation over time under uniaxial tension/shearing has been studied by adopting the Maxwell-Weichert model [3, 4]. The in-plane relaxation modulus has indicated a linear relationship with the relative density while the out-of-plane has illustrated a cubic polynomial relation with relative density. A simplified analytical model with solid elements has been developed aiming to obtain the analytical results of in-plane and out-of-plane relaxation moduli in terms of relative density. The numerical and analytical results have shown good agreement in the tendency.

REFERENCES

[1] Nam, S. and Hu, K. H. and Butte, M. J. et al. 2016. Strain-enhanced stress relaxation impacts nonlinear elasticity in collagen gels. *Proceedings of the National Academy of Sciences* 113(20), pp. 5492-5497.

[2] Ma, Y.H, Zhu, H.X. et al. 2018. The elasto-plastic behaviour of three-dimensional stochastic networks with cross-linkers, J. Mech. Phys. Solids, 110, pp. 155-172.

[3] Shen, Z. L. and Kahn, H. and Ballarini, R. et al. 2011. Viscoelastic properties of isolated collagen fibrils. *Biophysical journal* 100(12), pp. 3008-3015.

[4] Zhu, H.X. and Mills, N.J., 1997. Modelling the creep of open-cell polymer foams, J. Mech. Phys. Solids, 47, pp. 1437-1457.