A Predictive Model for the Design of Functional Textiles

C.N. Iliffe*, B.N. Bridgens* and P.D. Gosling*

*School of Civil Engineering and Geosciences
University of Newcastle upon Tyne,
Newcastle upon Tyne, NE1 7RU, UK
email: ben.bridgens@ncl.ac.uk, web page: http://www.ncl.ac.uk/ceg/

ABSTRACT

Functional textiles have a wide variety of uses including large scale roof structures (Bridgens et al., 2004), medical applications (Kharazi et al., 2010), and as reinforcement for composite materials. Functional textiles are typically manufactured based on simplified engineering requirements (e.g. weight and uniaxial strength), with other properties (such as detailed analysis of stiffness) determined retrospectively through physical testing. The work presented here demonstrates a methodology for the design of bespoke functional textiles to meet detailed engineering requirements, with the focus on the biaxial and shear response of flexible coated woven fabrics. The method employed uses a semi-analytical optimisation routine to determine the optimum fabric geometry and constituent material properties for detailed material stiffness requirements.

Previously developed mechanical ‘unit cell’ models have been shown to provide a good prediction of the response of architectural plain-weave fabrics under biaxial load, and have therefore formed the basis of the work (Bridgens, 2005). The derivatives of the unit cell equilibrium equations have been determined and this allows the fabric parameters to be optimised for a detailed set of biaxial and shear stiffness requirements at different stress levels. Initial validation using the model to design feasible, known fabrics has shown good results and demonstrated the potential utility of this approach.

Further work is ongoing to allow the optimum design of a fabric for a weighted set of design requirements which are unlikely to be completely feasible. The inherent uncertainty in the manufacturing process, and the discrete nature of some parameters, will also be considered.

REFERENCES

[1] Bridgens, B.N. (2005) Architectural fabric properties : determination, representation & prediction. University of Newcastle upon Tyne.

[2] Bridgens, B.N., Gosling, P.D. and Birchall, M.J.S. (2004) 'Membrane material behaviour: concepts, practice & developments', The Structural Engineer.

[3] Kharazi, A.Z., Fathi, M.H. and Bahmany, F. (2010) 'Design of a textile composite bone plate using 3D-finite element method', Materials & Design, 31(3), pp. 1468-1474.