Practical implementation of a thermo visco elastic material model for the design and analysis of ETFE structures

Adam Bown*†, Adrian Cabello†, Artem Holstov†

† Tensys Ltd, 122 Wells Road, Bath, UK - Web page: https://www.tensys.com/

ABSTRACT

The forthcoming Eurocode pertaining to membrane structures, CEN/TC 250, has gone to great efforts to harmonize material data and approaches relating to the design of ETFE structures. Before the development of this standard, anecdotal evidence suggested that there was a large variation in design philosophies for such structures, project to project.

The Eurocode follows a limit state approach, where permissible stresses are calculated for each loaded state under consideration, from a single characteristic strength, which is reduced using a series of partial factors that vary on a load case to load case basis.

In parallel to the above effort, the European Industrial Doctorate Project, *'Lighten'* [1], is undertaking physical testing and subsequent characterisation of ETFE, with the aim of developing a constitutive numerical model to predict the time and temperature dependent mechanical behaviour of this thermo visco-elastic material. The Lighten program was inspired by another recent research project which was used to characterize the visco-elastic behaviour of the thin polyethylene films, used as the gas barriers for various stratospheric balloon programs [2].

The model may be used to predict stresses in ETFE structures, under time dependent loading conditions. These stresses can be compared to the time, temperature and loading rate dependent, yield criterion, to assess the margins to plasticity.

As one of the industrial partners, Tensys has been closely monitoring the results of the Lighten program, with particular emphasis on how these valuable tools and modelling approach can effectively be applied in the design of ETFE structures, *whilst remaining within the design framework of the Eurocode*. There are challenges in attempting to reconcile the 'snapshot' approach of the Eurocode with the time and loading rate dependance inherent to visco elastic models.

This paper introduces the initial results delivered by the program; a linear visco-elastic material model, a yield criterion surface and a creep model, and describes how these tools may be used in conjunction with, and complement, the code-based approach.

REFERENCES

[1] https://lighten-itn.eu

[2] F. Bosi and S. Pellegrino, "Nonlinear thermomechanical response and constitutive modeling of viscoelastic polyethylene membranes", *Mechanics of materials 117 9-21,* (2018).