The Determination of the Mechanical Performance of Membrane Structures in Architectural Applications

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Abstract

For the design of membrane structures as building cladding systems detailed information about the mechanical performance of the membrane material as well as information of the mechanical performance of details and connections is a condition sine qua non. The mechanical engineering requires precise knowledge regarding the specific response of the membrane cladding material when exposed to external loads, wind loads in particular. Thus, a test procedure for the membrane material is required that simulates environmental load conditions.

Currently, the mechanical characterisation of membrane materials follows the test procedures given by DIN EN ISO 527-1-5 Plastics – Determination of tensile properties [1] or ASTM D638–22 Standard Test Method for Tensile Properties of Plastics [2]. Both test methods refer to a constant elongation speed of the membrane material in a mono-axial tensile test. This load condition does not exist in nature.

Wind loads are typically defined by a gust duration between 2 and 5 seconds. The basic wind load is approximately 60% of the maximum load. Thus, the response of the membrane material will be different compared to a test with a constant elongation speed.

Additionally, monoaxial tests of ETFE foils show a strong dependence on the test speed not just only regarding the Young's modulus but also regarding the so-called first and second yield point.

Fluoropolymers like ETFE foils when exposed to constant load speeds show a totally different performance. The Young's modulus is significantly enhanced and neither a first nor a second yield point can be identified.

Thus, the test procedures that are currently applied for the determination of the mechanical performance of membrane materials can not reflect the mechanical response of the membrane material when exposed to environmental loads (wind gusts). This article will introduce a new approach for the definition of the mechanical properties of membrane material by a simulation of real environmental loads.

Keywords: Membrane structures, ETFE foils, tensile tests, tensile strength, membrane specification, mechanical performance, load response, structural engineering

References

[1] DIN EN ISO 527-1-5 "Plastics – Determination of tensile properties", DIN Deutsches Institut für Normung e.V., Beuth-Verlag, Berlin 1996.

[2] ASTM D638 – 22 "Standard Test Method for Tensile Properties of Plastics", ASTM International, Beuth-Verlag, Berlin 2022.