Design-driven Uniaxial and Biaxial Tensile Testing of Knitted Fabrics Applied to Construction

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Abstract

Knitted fabrics are rarely subjected to tensile stress tests in the field of architectural construction materials, mostly due to their common use as drapery. However, recent non-standard applications of tensioned knitted textiles to hybrid lightweight constructions call for the assessment of their mechanical behavior. In the light of the absence of specific testing methodologies regarding knitted fabrics in the field of construction, this study aims at investigating customized testing techniques that target design requisites, as well as extending previous groundwork on plain weft-knitted textiles to tuck-loop knit structures. Fabrics with a piquet Lacoste loop structure are tested uniaxially and biaxially in order to estimate the feasibility of a relatively large-scale project. The challenging task consists of stretching the limited production width in weft direction to the extended dimensions of the tensile architectural project. Hence the study focuses on elongation limits and especially on the maximum elongation that allows elastic deformation. Extracted empirical data are expressed in the form of stress/strain curves that enable an appropriate understanding of the textiles' mechanical behavior. This inquiry points out the extent to which knit pattern favors directional elongation in warp as opposed to weft or vice-versa. In addition, it addresses the mechanical performance of knitted textiles by means of a strategic customization of tensile tests that can make them better at informing the design process and feasibility assessment.

Keywords: Knitted fabric, mechanical behavior, uniaxial test, biaxial test, elongation, piquet Lacoste, feasibility, tensile architecture.

1 Introduction

Knitted textiles have traditionally been used in the field of architecture, especially in interior design, in the form of small-scale draperies. This use came because of the ability of their textile alternatives, i.e. coated and woven fabrics, to provide higher rigidity and waterproofing in tensile large-scale structures. There have been however some attempts in the last decade to integrate knitted textiles in larger hybrid structures, mostly combined with bending active elements. These trials have exploited the high customization potential of the fabrics, both density-wise to structurally optimize them [1-5] and appearance-wise [6,7], as well as their ability to stretch to a high extent [8]. The high degree of flexibility of these form-active textiles is complementary to the internal bending-active forces inside fiber-reinforced elastic bars [1-3,6-8] or pneumatic elements [4,5], a mechanical behavior that cannot be replicated by stiffer coated or woven textiles.

Such recent developments call for an appropriate tensile testing method that would be useful to assess not only permissible loads, but also other more relevant properties to the actual application of knitted fabrics, for example maximum elongation and elastic deformation. The current applications of knitted textiles are in the context