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Understanding Light in Lightweight Fabric (ETFE Foil) Structures through Field Studies

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Abstract

This paper presents an experimental approach to investigate the luminous environment in lightweight fabric structures through field study. Buildings selected for the field study included the Engineering Science Learning Centre at the University of Nottingham and the Clarke Quay in Singapore.

By undertaking on site monitoring under different sky conditions in the chosen buildings with distinctively different site context, this research project explores how the typical homogeneously lit and rather dull luminous environment in lightweight fabric structure can be improved for enhanced visual interest, visual comfort, and three-dimensional modelling under both sunny and overcast sky conditions. Research data obtained from the subjective appreciation of the internal luminous environments and the quantitative spot measurement and mapping of light are compared and discussed.

This study concluded that selective use of transparent and translucent components in the ETFE envelope can offer architectural designers the opportunities to create well balanced, yet dynamic lit scenes. Also by combining single skin ETFE foil and the double or triple layered ETFE cushion and introducing ETFE cushions with different light transmittance to the building envelope can help improve the overall visual and luminous environment and enhance task illumination. The key findings from this research work are applicable to the design of light in lightweight fabric structure in general.

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Keywords: Lightweight Fabric Structures; ETFE cushion and foil, Luminous Environment; Field work.

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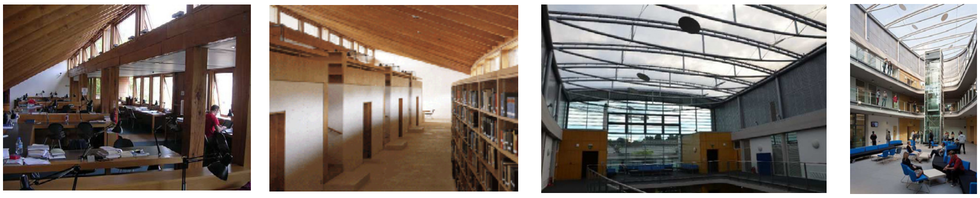
1. Introduction

Unlike more widely used heavy weight structures, which have perceptible brightness contrast in their internal spaces with relatively dark ceiling and brightly lit walls and floor (Figure 1 a & b), the luminous environment in tensile fabric structures is normally the opposite, with low brightness contrast and relatively uniformly illuminated ceiling, walls and floors (Figure 1 c & d). However, whether this kind of appearance is considered in itself to be good or bad will depend on the site context, the building programme and the function of the space. The perception and readability of the internal environment in these structures is dependent on the optical properties of the buiilding materials – the way they reflect, absorb or transmit visible light [1]. Thus, our understanding and design of the luminous environment in tensile fabric and ETFE foil-covered structures cannot be just based on the recommended illumination level alone. Designers need to understand the unique characteristics of the lit environment in these structures and strive to create interesting and well-balanced lighting conditions to suit the function of the space under the luminous roof and enhance task performance and visual comfort. By careful and well thought through manipulation of light, shadow and contrast, a lit scene which yields the required information and enhances visual perception can be created [2].



(a) (b) (c) (d)

Fig.1. (a & b) Darwin Library, University of Cambridge; (c & d) Engineering Science Learning Centre (ESLC), University of Nottingham.

2. Field Studies

In order to have a better understanding of the luminous environment under the lightweight fabric enclosure, field studies through spot measurements and light mapping were undertaken in two buildings: the Engineering Science Learning Centre at the University of Nottingham and the Clark Quay in Singapore.

2.1. Case Study A: Engineering Science Learning Centre at the University of Nottingham

This three-storey Engineering Science Learning Centre (ESLC) at the University of Nottingham contains student support office, graduate center, learning and teaching spaces and a multi-functional central atrium was designed by Hopkins Architects, UK in 2011. The atrium roof consists of three layer ETFE cushions with fritted top layer (200µm), transparent middle layer (150µm) and bottom layer (150µm) and they are edge clamped to the extruded aluminum frames connected to the primary steel truss structure. The building envelope is protected by horizontally attached louvers that help to reduce both solar ingress and solar gain on the glazed façades, and the geometry of this building has an arch-shape in plan with a central atrium of 330 m^2. The ETFE roof provides daylight mainly to the atrium and the circulation spaces, and a glazed aperture on the top part of the south west façade offers supplementary daylight (Figure 1 c & d).