NATURE INSPIRED ARCHITECTURE:
INTEGRATIVE COMPUTATIONAL DESIGN AND FABRICATION FOR FILAMENTOUS STRUCTURES

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Inspiration found in nature, together with advances in computational design and robotic fabrication, challenge existing approaches in building technology in a surprising manner, or even point out completely different possibilities. Biology offers an almost inexhaustible reservoir of principles of form, structure and process that can be transferred to architecture. At the same time, computation profoundly transforms the building industry. Our presentation will introduce ways of tapping the full potential of digital technologies in architecture and construction through inspiration by nature, in order to go beyond the mere digitalization of established planning procedures and the automation of existing building processes towards truly integrative computational design and construction. Along the example of large-scale, load-bearing, fiber-composite structures, we will show how a biomimetic approach enables creating architecture that is both highly effective and efficient, as well as explorative and expressive.

Diversity constitutes a key feature of living nature. Highly differentiated, finely tuned and infinitely varied systems are unfolding from evolutionary development. Given this vast range of natural variation, it may come as a surprise that almost all load-bearing biological structures are fibrous composites. They are all made-up of filamentous elements embedded in a matrix material. While these two elements remain distinct in the composite material, their combination yields properties and performances superior to each of the two constituting parts. In this way, natural composites fundamentally work in a similar manner as man-made, technological composites, such as glass or carbon fibre-reinforced plastics. This correspondence in basic composition and characteristics renders fibrous composites as prime candidates for biomimetic design research that investigates how the principles of fibrous organisation in biology can be transferred to composite systems in architecture.

We will present interdisciplinary research of the Institute for Computational Design and Construction at the University of Stuttgart that seeks to bridge between the technical dimension of fibrous systems in architecture and the rich repertoire of fibrous morphology in nature. Based on advanced design computation, simulation and robotic fabrication these explorations open-up a new approach to fibre-reinforced composite structures. This will be introduced along the example for several full-scale demonstrator buildings, which are made entirely from load-bearing fibre composite components. They are each produced from glass and carbon fibres through novel, robotic additive fabrication processes, which allow for the specific adaptation of form and fibre layout for each individual building element depending on its structural and architectural requirements.

Figure 1 – Robotic filament winding of large-scale building elements

Figure 2 – Full-scale research demonstrator: Elytra Filament Pavilion, V&A London