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Abstract

Diatom Frustule-Inspired Bridges: A Fusion of Art, Architecture and Mechanical Design †

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Abstract: Bridges are important structures, often playing a vital role in society, connecting communities, enabling easy access over complex terrains and providing aesthetic purpose. Bridges are therefore infrastructurally, socially and psychologically beneficial to society. As such, there is importance in considering structural aspects alongside architectural aesthetics when designing bridges. Structures in nature often have coupled benefits. Many structures are aesthetically pleasing to the human eye, whilst also serving structural and mechanical roles. In this paper, we explore beauty in the form and structure of diatoms. We take a bioinspired approach to bridge design by computationally imitating and integrating the complex geometrical pattern of diatom frustules into the bridge design. Diatoms are single-celled algae that are protected by bioglass frustules, each of which exhibits architectural symmetry and porosities. In parallel to designing the aesthetics of bridges, as inspired by diatom frustules, we concurrently parametrically design these architectures to improve the mechanical rigidity of the final bridge forms. Our abstraction from diatom to bridge follows similar principles to analogical KoMBi models, considering specifically geometrical pore features from diatom species alongside their spatial distances and size variations. These abstractions are thus low-level abstractions focusing on geometrical properties such that their geometrical requirements are understood alongside their aesthetic and lightweight biological functions, which are subsequently transferred to bridge design either directly or in convoluted forms. Our initial designs are developed using non-uniform rational B-spline (NURBS) surfaces (Rhino-3D), and selected bridge forms are then modelled using the finite element analysis (FEA) method to ascertain optimal hole sizes and positions (COMSOL Multiphysics) in relation to their fundamental mechanical properties such as tensile and compressive strength and stiffness. Our results yield innovative, artistic and efficient bridge architectures optimised for structural integrity and load bearing.

Keywords: diatom; bridge; design; art; architecture

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