New style of arch bridge architecture shaped by nature

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A mock-up of a constant stress arch on the University of Warwick campus. Credit: University of Warwick

A new style of arch bridges that are more robust than ever and inspired by nature have been found by a researcher from the University of Warwick.

Emeritus Professor Wanda Lewis from the School of Engineering at the University of Warwick has used the principle of constant stress to shape arch bridges subjected to a permanent load, ie. their own weight.

The concept of the arch bridges has been explored in the paper, "Constant stress arches and their design space," published in the journal *Proceedings of the Royal Society A*.

Constant stress is observed in natural shaping objects such as trees, shells or bones, as they are objects that are well known to be highly optimized in terms of their high strength-to-mass ratio.

Using a reverse-engineering design processes in which the shape of a structure is determined through a process of form-finding, a constant stress arch is presented. It is a moment-less form, which means it responds to permanent load in a simplest possible way by generating only axial stress without bending action, and a constant value of stress which the cross-section area can accommodate.

Although constant stress arches may present a construction challenge, due to their continually varied cross-section and high level of accuracy required in manufacture, their simple response to loading has the potential to solve durability and sustainability problems facing our future infrastructure.

A model of a constant stress arch. Credit: University of Warwick

Professor Wanda Lewis from the School of Engineering at the University of Warwick comments:

"Over the last thirty years I have been researching how to make robust structures that are stronger than ever by using form finding and applying constant stress inspired by shapes found in nature.

"The new type of arch bridge style is therefore not only strong, but a natural formation presenting a new style of architecture."

Further work will be conducted to investigate arch stability, and propose

appropriate levels of constant stress, so that the arches don't exceed their design strength limits when subjected to the ultimate load or become too heavy when the chosen value of stress is too low.

More information: Wanda J. Lewis, Constant stress arches and their design space, *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* (2022). DOI: 10.1098/rspa.2021.0428

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