Mike Barnes's legacy: the emergence of form finding and analysis approaches for bending active and elastic grid shell structures

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Abstract

Michael (Mike) Barnes was the Head of the Department of Architecture and Civil Engineering at Bath University (UK) in the late 90's. During that period, he was my Ph.D. advisor and I was his last PhD student. At the end of the 20th century, the interest in lightweight structures had revived in the UK due to the realization of a number of Millenium projects and this context made Mike's research interests of high societal relevance . Together with Mike and dr. Chris. J. K. Williams, my other PhD advisor, we developed and validated an algorithm for a beam element that could be incorporated in the dynamic relaxation process. With the addition of the beam element, the morphogenesis of a whole new series of structures, namely elastic gridshells and even more global "bending active" structures was enabled. I would like to demonstrate the legacy of Mike's work on academia, industry and the design community. First, the PhD thesis resulted in a journal paper "Tensegrity spline beam and grid shell structures" [1]. This paper lays the basis for further developments of beam and beam/torsion elements for non-linear structures [2]. The paper also demonstrated the beneficial strain hardening effect in spline or what would now be called "bending active" structures. Bending active structures have now become a new and large research domain, also within IASS. Much later, we published a follow-up paper "A novel torsion/bending element for dynamic relaxation modeling" [3]. Second, these algorithms were key to the form finding of the Dutch Marine Museum courtyard gridshell (Amsterdam, Netherlands, 2006). This faceted steel/glass shell resulted from a design competition won by the Belgian firm Ney and Partners. The topology of the shell lattice is based a 17th century loxidrome map, the form of the lattice shell is generated using hanging chain model combined with beam elements to achieve a very efficient form. The shell won a number of architectural awards and was lauded for its extreme slenderness, an attribute that could only be achieved through the form finding algorithms [4]. Finally, the initial paper [1] was picked up by the parametric design community and converted by Daniel Piker into the Kangaroo plugin for Grasshopper. Kangaroo is a Live Physics engine for interactive simulation, form-finding, optimization and constraint solving and has been downloaded more than 350 000 times and taught in many Digital Design Courses in Architecture Schools worldwide. For example, these algorithms are also being explored in my graduate course "Form Finding of Structural Surfaces " [5] and were used for one of the winning designs of the IASS Young Engineer Design Competition for the Tokyo Olympic Stadium . The impact of Kangaroo (and hence the algorithms) on the parametric design community is difficult to measure but I am convinced that those algorithms have and will continue to shape contemporary architectural engineering. The examples I have discussed, show the importance of the questions that Mike asked and solved as well as the impact his findings had on the construction industry, the development of new research domains and design thinking of new generations of architects and engineers.

References

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